Hrng Span

Oct 28 - Dec 27

December 13, 1974

Ms. Harriet C. Minami
Akahi Place
Lanai, Hawaii 96763

Dear Ms. Minami:

Pursuant to Mr. Dennis Hokama's memo dated December 5, 1974 requesting for withdrawal of A74-376 Harriet Minami, etal petition, we have withdrawn this petition to amend the Land Use District boundaries for the island of Lanai. Therefore, the Land Use Commission has cancelled the public hearing that was scheduled to be held on December 27, 1974 in the Lanai High and Elementary School Cafetorium, Lanai City, Lanai to receive any testimony from any interested parties.

Should you have any further questions, please do not hesitate to contact us.

Very truly yours,

TATSUO FUJIMOTO
Executive Officer

Enclosure
cc: Howard Nakamura
Donald Rietow
James Funaki
Dennis Hokama
Sam Shin

bcc: LUC
All petitioners listed in A74-376 file

December 13, 1974

Mrs. Jane L. Gabriel
Lanai Community School Library
P. O. Box A-149
Lanai City, Lanai 96763

Dear Mrs. Gabriel:

This is to inform you that Mr. Dennis Hokama, representing the petitioners of A74-376, Harriet Minami, etal, has withdrawn their petition that is before the Land Use Commission. Therefore, the public hearing on this matter that was scheduled for December 27, 1974 at 3:00 p.m., at the Lanai High and Elementary School Cafetorium, Lanai City, Lanai, has been cancelled.

We would appreciate your inserting this information in the subject file for public use purposes.

Thank you for your continued cooperation.

Very truly yours,

TATSUO FUJIMOTO
Executive Officer

Enclosures

memo

from dennis hokama 6811

to State Land Use Commission room

re Lanai Downzoning Petition date 12/5/74

time

Mr. Fujimoto:

I, Dennis Hokama, request withdrawal of the Lanai Downzoning petition which will be resubmitted in a possible modified format at a later date.

Dennis Hokama

Dennis Hokama

Address: 2029 Leiloke Dr.
Hon., Hawaii 96822

Ph. 536-1127

RECEIVED
DEC 5 1974
State of Hawaii
LAND USE COMMISSION

memo

from dennis hokama 6811

to State Land Use Commission room

re Lanai Downzoning Petition date 12/5/74

time

Mr. Fujimoto:

I, Dennis Hokama, request withdrawal of the Lanai Downzoning petition which will be re-submitted in a possible modified format at a later date.

Dennis Hokama

Dennis Hokama

Address: 2029 Leiloke Dr.
Hon., Hawaii 96822

Ph. 536-1127

RECEIVED
DEC 5 1974
State of Hawaii
LAND USE COMMISSION

LEGAL NOTICE

NOTICE OF PUBLIC HEARING

TO CONSIDER PETITIONS FOR CHANGE OF DISTRICT BOUNDARIES WITHIN THE COUNTY OF MAUI BEFORE THE LAND USE COMMISSION OF THE STATE OF HAWAII

NOTICE IS HEREBY GIVEN of the public hearings to be held in the County of Maui by the Land Use Commission of the State of Hawaii to consider petitions for change of district boundaries as provided for in Section 205-4, Hawaii Revised Statutes.

DATES, TIMES AND PLACES:

Island of Molokai
December 27, 1974 — 9:30 a.m.
Kaunakakai School Cafetorium
Kaunakakai, Molokai

Island of Lanai
December 27, 1974 — 3:00 p.m.
Lanai High & Elementary School Cafetorium
Lanai City, Lanai

Docket Number and Petitioner: A74-376— ✓ Cancelled
Harriet Minami, etal

Tax Map Key: 4-9 (portions) Island of Lanai

Change Requested: To delete approximately 1,620 acres from the Urban District. To delete approximately 2,720 acres from the Rural District. To delete approximately 18,000 acres from the Agricultural District. To add approximately 22,340 acres to the Conservation District.

Docket Number and Petitioner: A74-377—
Samuel M. Peters, etal

Tax Map Key: 2-5-1: 02 (portions)

Change Requested: To incorporate approximately 3,305 acres presently in the Urban District into the Agricultural District at Kaluakoi, Molokai.

Maps showing the areas under consideration for change of district boundaries and copies of the Rules and Regulations governing the petitions above are on file in the office of the Maui Planning Department, County of Maui; and the Land Use Commission; and are open to the public during office hours, Monday through Friday.

Maps relating to Docket A74-376 Harriet Minami, etal are available for public inspection at the Lanai Community School Library, Lanai City, Lanai.

Maps relating to Docket A74-377 Samuel M. Peters, etal are available for public inspection at the Molokai Branch, Maui Public Library, Kaunakakai, Molokai.

At the hearings, interested owners, lessees, officials, agencies, and individuals may appear and be heard and shall further be allowed to file with the Land Use Commission a written protest or other comments on recommendations before or during the public hearings, or up to fifteen (15) days following their close.

All written protests or comments regarding the above petitions may be filed with the Land Use Commission, Kamamalu Building, P.O. Box 2359, Honolulu, Hawaii, 96804, before or during the public hearings, or up to fifteen (15) days following the public hearings.

LAND USE COMMISSION
EDDIE TANGEN, Chairman
TATSUO FUJIMOTO, Executive Officer

(S.-B.: Dec. 6, 1974) (SB-2178)

December 5, 1974

Mrs. Jane L. Gabriel
Lanai Community School Library
P. O. Box A-149
Lanai City, Lanai 96763

Dear Mrs. Gabriel:

Transmitted for your information and public use is an application from Harriet Minami, etal, Docket No. A74-376 to the Land Use Commission for change of district boundary as outlined within the petition. A public hearing on this matter will be taken up on December 27, 1974 at 3:00 p.m., in the Lanai High and Elementary School Cafetorium, Lanai City, Lanai. (See attached copy of public hearing notice.)

We would appreciate your cooperation in making this file available to the public upon request. Thank you for your continued cooperation.

Very truly yours,

TATSUO FUJIMOTO
Executive Officer

Enclosures

6762

JOHN A. BURNS
GOVERNOR OF HAWAII

STATE OF HAWAII
DEPARTMENT OF HEALTH
P. O. BOX 3378
HONOLULU, HAWAII 96801

WALTER B. QUISENBERRY, M.P.H., M.D.
DIRECTOR OF HEALTH

WILBUR S. LUMMIS JR., M.S., M.D.
DEPUTY DIRECTOR OF HEALTH

RALPH B. BERRY, M.P.H., M.D.
DEPUTY DIRECTOR OF HEALTH

HENRI P. MINETTE, M.P.H., DR.P.H.
DEPUTY DIRECTOR OF HEALTH

November 8, 1974

RECEIVED
NOV 12 1974
State of Hawaii
LAND USE COMMISSION

M E M O R A N D U M

To: Tatsuo Fujimoto, Executive Officer
Land Use Commission

From: Director of Health

Subject: Proposed Boundary Amendments

✓ A74-376	Lanai
A74-377	Molokai
A74-378	Kawainui Swamp

Pursuant to your request for comments dated October 25, 1974 we have referred the proposals for Lanai and Molokai to our District Health Office on Maui for comments, which will be transmitted to you upon receipt.

We concur in your proposal to redistrict the described 230 acres of land in the Kawainui Swamp area from Urban to Conservation designation for the reasons set forth in your recommendations.

Walter B. Quisenberry
Walter B. Quisenberry, M.D.

cc: Maui District Health Office

Form B-24

STATE OF HAWAII

OFFICIAL RECEIPT **Nº 0026**

Department of Planning and Economic Development
Department, Bureau or Commission

Sept. 6, 19 74

RECEIVED from Dennis S. Hokama

One Hundred and 00/100 DOLLARS

LUC Petitioner's Fee.

$ 100.00

Caroline Okuda
Public Accountant

Samuel M. Peters, et al
Harriet Minami, et al ✓

Form B-24

STATE OF HAWAII

OFFICIAL RECEIPT **№ 0871**

Land Use Commission

Department, Bureau or Commission

September 3, 1974

RECEIVED from Dennis S. Hakama

Fifty and no/100 DOLLARS

Boundary change Petition - Harriet Minami, et al

$ 50.00

L. Moon

Public Accountant

STATE OF HAWAII
LAND USE COMMISSION
P. O. BOX 2359
HONOLULU, HAWAII 96804

September 3, 1974

Planning Commission
County of Maui
200 South High Street
Wailuku, Maui 96793

Attention: **Mr. Howard Nakamura**
Planning Director

Subject: **A74-376 - Harriet Minami, Et Al**

Gentlemen:

Pursuant to Section 205-4, Hawaii Revised Statutes, we are enclosing a copy of petition for amendment to the land use district boundaries submitted by **Harriet Minami, et al**.

Act 32 provides that within 45 days after receipt of the petition, the Commission of the County wherein the land is located shall forward its comments and recommendations to the Land Use Commission. It also provides that upon written request by the Planning Commission, the Land Use Commission may grant an extension of not more than 15 days for the receipt of such comments and recommendations.

Very truly yours,

TATSUO FUJIMOTO
Executive Officer

Encls.

STATE OF HAWAII
LAND USE COMMISSION
P. O. BOX 2359
HONOLULU, HAWAII 96804

September 3, 1974

Ms. Harriet C. Minami
Akahi Place
Lanai, Hawaii 96763

This will acknowledge the receipt of your check in the amount of $50.00 and your application to amend the land use district boundaries at Lanai, Hawaii.

In accordance with Section 205-4, Hawaii Revised Statutes, this Commission must schedule a public hearing on your petition no sooner than 60 days and no more than 120 days. After 45 but within 90 days following the public hearing, the Land Use Commission is obliged to render a decision on your petition.

A hearing schedule will be determined at a later date to consider the several pending petitions, including yours, in the County of Maui. We will inform you of the hearing date as soon as it is determined.

Should any questions develop in the meantime, we will contact you. If you should have any questions, please feel free to contact us.

Very truly yours,

TATSUO FUJIMOTO
Executive Officer

Encl.
cc: Maui Planning Commission

This space for LUC use

Date Petition and Fee received by LUC ______________

Date forwarded to County for recommendation ______________

Date Petition, and County recommendation received by LUC ______________

STATE OF HAWAII
LAND USE COMMISSION

P. O. Box 2359
Honolulu, Hawaii 96804

A74-376

PETITION FOR AMENDMENT TO THE LAND USE COMMISSION DISTRICT BOUNDARY

(I) (We) hereby request an amendment to the Land Use Commission District Boundary respecting the County of Maui, Island of Lanai, map number and/or name TMK 4-9 (with exceptions see attachments) to change the district designation of the following described property from its present classification in a(n) ______________ district into a(n) ______________ district.

RECEIVED
AUG 29 1974
State of Hawaii
LAND USE COMMISSION

Description of property:

See attached explanation.

Petitioner's interest in subject property:

The petitioners are landowners, lessees and residents of Lanai

Petitioner's reason(s) for requesting boundary change:

See attached explanations.

(1) The petitioner will attach evidence in support of the following statement:

The subject property is needed for a use other than that for which the district in which it is located is classified.

(2) The petitioner will attach evidence in support of either of the following statements (cross out one):

(a) The land is usable and adaptable for the use it is proposed to be classified.

(b) Conditions and trends of development have so changed since adoption of the present classification, that the proposed classification is reasonable.

Signature(s) Joe Barbadillo

Interest in subject: Lessee

Address: Box 20 Lanai Ave.

Telephone: 565-6226

This space for LUC use

Date Petition and Fee received by LUC ________

Date forwarded to County for recommendation ________

Date Petition, and County recommendation received by LUC ________

STATE OF HAWAII
LAND USE COMMISSION

P. O. Box 2359
Honolulu, Hawaii 96804

A74-376

PETITION FOR AMENDMENT TO THE LAND USE COMMISSION DISTRICT BOUNDARY

(I) (We) hereby request an amendment to the Land Use Commission District Boundary respecting the County of Maui, Island of Lanai, map number and/or name TMK 4-9(with exceptions see attachments) to change the district designation of the following described property from its present classification in a(n) ________ district into a(n) ________ district.

RECEIVED
AUG 29 1974
State of Hawaii
LAND USE COMMISSION

Description of property:

See attached explanation.

Petitioner's interest in subject property:

The petitioners are landowners, lessees and residents of Lanai

Petitioner's reason(s) for requesting boundary change:

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(1) The petitioner will attach evidence in support of the following statement:

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(a) The land is usable and adaptable for the use it is proposed to be classified.

(b) Conditions and trends of development have so changed since adoption of the present classification, that the proposed classification is reasonable.

Signature(s) Tom Urpani Jr.
Tom Urpani, Jr.

Interest in subject: Lanai Overseas LESSEE

Address: 253 Gay St

Telephone: 565-5935

STATE OF HAWAII
LAND USE COMMISSION

P. O. Box 2359
Honolulu, Hawaii 96804

This space for LUC use

Date Petition and Fee received by LUC ______________

Date forwarded to County for recommendation ______________

Date Petition, and County recommendation received by LUC ______________

A74-376

PETITION FOR AMENDMENT TO THE LAND USE COMMISSION DISTRICT BOUNDARY

(I) (We) hereby request an amendment to the Land Use Commission District Boundary respecting the County of Maui, Island of Lanai, map number and/or name TMK 4-9(with exceptions see attachments) to change the district designation of the following described property from its present classification in a(n) ______________ district into a(n) ______________ district.

RECEIVED
AUG 29 1974
State of Hawaii
LAND USE COMMISSION

Description of property:

See attached explanation.

Petitioner's interest in subject property:

The petitioners are landowners, lessees and residents of Lanai.

Petitioner's reason(s) for requesting boundary change:

See attached explanations.

(1) The petitioner will attach evidence in support of the following statement:

The subject property is needed for a use other than that for which the district in which it is located is classified.

(2) The petitioner will attach evidence in support of either of the following statements (cross out one):

(a) The land is usable and adaptable for the use it is proposed to be classified.

(b) Conditions and trends of development have so changed since adoption of the present classification, that the proposed classification is reasonable.

Signature(s) Margarita Cabato
Cabalo
____

Interest in subject: LESSEE

Address: 537 Fifth St.

Telephone: 565-3291

STATE OF HAWAII
LAND USE COMMISSION

P. O. Box 2359
Honolulu, Hawaii 96804

A74-376

This space for LUC use

Date Petition and Fee received by LUC ____________

Date forwarded to County for recommendation ____________

Date Petition, and County recommendation received by LUC ____________

PETITION FOR AMENDMENT TO THE LAND USE COMMISSION DISTRICT BOUNDARY

(I) (We) hereby request an amendment to the Land Use Commission District Boundary respecting the County of Maui, Island of Lanai, map number and/or name TMK 4-9(with exceptions see attachments) to change the district designation of the following described property from its present classification in a(n) ____________ district into a(n) ____________ district.

RECEIVED
AUG 29 1974
State of Hawaii
LAND USE COMMISSION

__Description of property:__

See attached explanation.

__Petitioner's interest in subject property:__

The petitioners are landowners, lessees and residents of Lanai

__Petitioner's reason(s) for requesting boundary change:__

See attached explanations.

(1) The petitioner will attach evidence in support of the following statement:

The subject property is needed for a use other than that for which the district in which it is located is classified.

(2) The petitioner will attach evidence in support of __either__ of the following statements (cross out one):

(a) The land is usable and adaptable for the use it is proposed to be classified.

(b) Conditions and trends of development have so changed since adoption of the present classification, that the proposed classification is reasonable.

Signature(s) Sam Shin
____

Interest in subject: Land owner

Address: 520 Lanai Ave.

Telephone: 565-5201

PETITION FOR AMENDMENT TO THE LAND USE COMMISSION DISTRICT BOUNDARY:

re: County of Maui, Island of Lanai, TMK 4-9 (excluding Lanai City and other areas specified in attachment).

Signature: Harriet C. Minami

Interest in subject: land-owner

Address: Akahi Place

Telephone: 565-6121

RECEIVED
AUG 29 1974
State of Hawaii
LAND USE COMMISSION

PETITION FOR AMENDMENT TO THE LAND USE COMMISSION DISTRICT BOUNDARY:

re: County of Maui, Island of Lanai, TMK 4-9 (excluding Lanai City and other areas specified in attachment).

Signature: Manuel Pirao Jr.
Land Owners

Interest in subject: ________

Address: Hau 438

Telephone: 565 - 2343

RECEIVED
AUG 29 1974
State of Hawaii
LAND USE COMMISSION

PETITION FOR AMENDMENT TO THE LAND USE COMMISSION DISTRICT BOUNDARY:

[illegible]: County of Maui, Island of Lanai, TMK 4-9 (excluding Lanai City and other areas specified in attachment).

Signature: Helen Pavao
Land owners

Interest in subject: ______

Address: 438 Hau Place

Telephone: 565-2343

RECEIVED
AUG 29 1974
State of Hawaii
LAND USE COMMISSION

PETITION FOR AMENDMENT TO THE LAND USE COMMISSION DISTRICT BOUNDARY:

re: County of Maui, Island of Lanai, TMK 4-9 (excluding Lanai City and other areas specified in attachment).

Signature: Elizabeth Ramis

Interest in subject: Lessee

Address: 1244 Ilima Ave.

Telephone: 565-7661

RECEIVED
AUG 29 1974
State of Hawaii
LAND USE COMMISSION

PETITION FOR AMENDMENT TO THE LAND USE COMMISSION DISTRICT BOUNDARY:

re: County of Maui, Island of Lanai, TMK 4-9 (excluding Lanai City and other areas specified in attachment).

Signature: Sumiko Oge

&

Interest in subject: Land Owner

Address: 1336 Fraser Ave.

Telephone: 565-2785

RECEIVED
AUG 29 1974
State of Hawaii
LAND USE COMMISSION

PETITION FOR AMENDMENT TO THE LAND USE COMMISSION DISTRICT BOUNDARY:

re: County of Maui, Island of Lanai, TMK 4-9 (excluding Lanai City and other areas specified in attachment).

Signature: Theresa Pajo
Fausto Pajo

Interest in subject: Land Owner

Address: 1344 Fraser Ave.

Telephone: 565-2782

RECEIVED
AUG 29 1974
State of Hawaii
LAND USE COMMISSION

PETITION FOR AMENDMENT TO THE LAND USE COMMISSION DISTRICT BOUNDARY:

re: County of Maui, Island of Lanai, TMK 4-9 (excluding Lanai City and other areas specified in attachment).

Signature: Mr. & Mrs. James Wong
James Wong

Interest in subject: Land owner

Address: 227 Ilima pl. Lanai

Telephone: 5653322

RECEIVED
AUG 29 1974
State of Hawaii
LAND USE COMMISSION

PETITION FOR AMENDMENT TO THE LAND USE COMMISSION DISTRICT BOUNDARY:

re: County of Maui, Island of Lanai, TMK 4-9 (excluding Lanai City and other areas specified in attachment).

Signature: Beatrice Burgos
Frank Burgos

Interest in subject: land-owner

Address: 1030 Olapa St. - P.O. Box 403

Telephone: 565-5162

RECEIVED
AUG 29 1974
State of Hawaii
LAND USE COMMISSION

PETITION FOR AMENDMENT TO THE LAND USE COMMISSION DISTRICT BOUNDARY:

re: County of Maui, Island of Lanai, TMK 4-9 (excluding Lanai City and other areas specified in attachment).

Signature: Antone Mendes

Interest in subject: Land Owner

Address: 1120 Palawai Lane

Telephone: 565-2293

RECEIVED
AUG 29 1974
State of Hawaii
LAND USE COMMISSION

PETITION FOR AMENDMENT TO THE LAND USE COMMISSION DISTRICT BOUNDARY:

re: County of Maui, Island of Lanai, TMK 4-9 (excluding Lanai City and other areas specified in attachment).

Signature: Jonona M. Kahaleoumi

Interest in subject: INterested

Address: 84-1132A Lahaina St.

Telephone: None

STATE OF HAWAII
LAND USE COMMISSION
P. O. BOX 2359, HONOLULU, HAWAII 96804

U.S. POSTAL SERVICE, HI 967
-PM
16 DEC
1974
2A

Mr. Benjamin ?
954 Palawai Lane
Lanai, Hawaii 96763

REASON CHECKED
Unclaimed____ Refused____
Unknown ✓____
Insufficient address____
Moved, Left no address____
No such post office in state____
Do not remail in this envelope

Minami, etal file

December 13, 1974

Ms. Harriet C. Minami
Akahi Place
Lanai, Hawaii 96763

Dear Ms. Minami:

Pursuant to Mr. Dennis Hokama's memo dated December 5, 1974 requesting for withdrawal of A74-376 Harriet Minami, etal petition, we have withdrawn this petition to amend the Land Use District boundaries for the island of Lanai. Therefore, the Land Use Commission has cancelled the public hearing that was scheduled to be held on December 27, 1974 in the Lanai High and Elementary School Cafetorium, Lanai City, Lanai to receive any testimony from any interested parties.

Should you have any further questions, please do not hesitate to contact us.

Very truly yours,

TATSUO FUJIMOTO
Executive Officer

Enclosure
cc: Howard Nakamura
Donald Rietow
James Funaki
Dennis Hokama
Sam Shin

bcc: LUC
All petitioners listed in A74-376 file ✓

PETITION FOR AMENDMENT TO THE LAND USE COMMISSION DISTRICT BOUNDARY:

re: County of Maui, Island of Lanai, TMK 4-9 (excluding Lanai City and other areas specified in attachment).

Signature: [signature]

Interest in subject: Lessee

Address: 954 Palawai Lane.

Telephone: 565-6076

RECEIVED
AUG 29 1974
State of Hawaii
LAND USE COMMISSION

PETITION FOR AMENDMENT TO THE LAND USE COMMISSION DISTRICT BOUNDARY:

re: County of Maui, Island of Lanai, TMK 4-9 (excluding Lanai City and other areas specified in attachment).

Signature: Pedencio P. Lapoza Jr.
Marcelina Lapaga

Interest in subject: lessee

Address: 452 Ilima Ave.

Telephone: 565-2372

RECEIVED
AUG 29 1974
State of Hawaii
LAND USE COMMISSION

PETITION FOR AMENDMENT TO THE LAND USE COMMISSION DISTRICT BOUNDARY:

re: County of Maui, Island of Lanai, TMK 4-9 (excluding Lanai City and other areas specified in attachment).

Signature: Angelina Asuncion

Interest in subject: land owner

Address: 1010 Naha St

Telephone: —

Dean Del Rosario
P.O. Box 1023
Lanai City, HI
96763

Land Use Commission
1010 Richards Street
Honolulu, Hawaii
96813

RECEIVED
AUG 29 1974
State of Hawaii
LAND USE COMMISSION

Members of the Land Use Commission,

Your acceptance of our petition to redistrict lands on the island of Lanai is greatly appreciated. We feel that we have provided valid and sufficient evidence to support our request.

The redistricting petition is for amending the land use boundaries on portions of Tax Map Key 4-9, section map, island of Lanai. We request the Commission to:

1) delete approximately 1,620 acres from the Urban district, and
2) delete approximately 2,720 acres from the Rural district, and
3) delete approximately 18,000 acres from the agriculture district,

District symbol circled with red ink.

4) add approximately 22,340 acres to the Conservation district.

In essence, petitioners ask for a reversal of the decision granted to the Lanai Company as related in file A72-349 and as decided by the Commission on May 5, 1973.

Dennis Hokama, a former resident of Lanai, now living on Oahu, has agreed to submit our petition for us. The time and expense involved in sending a member of our group to personally submit the petition would be a great hardship on our part.

Please forward all correspondences to Dean Del Rosario whose address is written above and to Dennis Hokama whose address is 2029 Leiloke Drive, Honolulu, Hawaii 96822.

Yours Sincerely,

LANAI PETITIONERS

LANAI REDISTRICTING PETITION

Petitioners request the State Land Use Commission for a district boundary amendment as provided for in section four, Chapter 205, Hawaii Revised Statutes, and in Rule 1.21, Sub-Part C, Part One, Rules of Practice and Procedure, State Land Use Commission. Section 205-4 states that "...any property owner or lessee may petition the land use commission for a change in the boundary of any district." (emphasis added). Rule 1.21(a) states that "...any owner and lessee and any interested person... may petition the Commission for the amendment of established district boundaries..." (emphasis added).

Petitioners meet the conditions of section 205-4 and Rule 1.21 for petitioning the Land Use Commission to amend certain district boundaries on the island of Lanai.. Petitioners are: property owners, satisfying section 205-4 and Rule 1.21(a); lessees, satisfying section 205-4 and Rule 1.21(a); and an interested person, satisfying Rule 1.21(a). Furthermore, petioners have an extraordinary interest and concern in this boundary amendment petition above and beyond that required by section 205-4 and Rule 1.21(a). Petitioners are property owners and lessees who reside near the property sought to be changed and will be affected and benefited by the proposed use of the property. Furthermore, petitioners note the recent Hawaii Loa ridge case decided by Judge Norito Kawakami in which "The Court is of the view that...any property owner or lessee who resides near the property sought to be changed and who could be affected by the use of the property has a right under the statute to petition for change of designation."

Lastly, petitioners note that the Lanai Company was granted its request for redistricting as an interested person provided for in Rule 1.21. Lanai Company did not own or lease the subject property ~~and~~ nor do we know that Lanai Company owns or leases any land.

Petitioners feel fully entitled to petition the Commission for an amendment to the land use district boundaries on Lanai island.

PETITION FOR AMENDMENT OF CERTAIN DISTRICT BOUNDARIES ON LANAI ISLAND

The purpose of this petition is to request changes in district boundaries on land owned by Castle and Cooke, island of Lanai, Tax Map Key 4-9 . This land is currently districted as urban, rural, and agriculture. We, the petitioners, herewith request the Land Use Commission to district this land agriculture and conservation. In essence, we request a rollback on the districting granted to Lanai Company in May 1973 (file number).

We the petitioners, who are landowners, lessees, and interested persons of Lanai, have distinct property, economic personal and environmental interests and concerns in the subject property and the proposed redistricting. Our interests and concerns are affected by the subject property and the proposed redistricting will affect those interests and concerns. These interests and concerns are manifold and extensive.

Most of us were born and raised on Lanai or have spent the greater part of our lives on Lanai. We have been privileged to live a rural lifestyle that only Lanai could provide. Through the proposed redistricting, we will secure and protect that lifestyle for ourselves, our children and their children.

The subject property is for a resort-residential development. It is our belief, and past experiences have shown, that the prices of land will be driven up because of that kind of development, thus raising the price of land and homes that we desire to buy, and in the process raising property taxes and rental fees. Our property interest will be adversely affected because of the Lanai Company development on the subject property. Additionally, the proposed redistricting will benefit our property interests by preventing the rising prices and property taxes, thus enabling us to continue the rural lifestyle living so characteristic of Lanai and so valuable to us.

Our interests and concerns extend to Hulopoe beach, the most accessible, the safest for camping and water sports, and the most beautiful beach on Lanai. This beach is a family beach. It is the only beach safe enough for our children to swim in and it is our only surfing spot on the island. Hulopoe beach is the weekend recreation area for all Lanai people. Many local people enjoy this beach every day. Redistricting this beach and surrounding area to conservation will preserve and protect this important facet of our lives. Resort and second-home development in this area will only destroy this condition and make our most popular beach a commodity for tourists and land speculators to exploit.

Another example is the beach between Naha and Keomoku. This stretch of beach is the most popular for fishing and camping because of its relative accessibility, excellent fishing, the safeness of the area, and very importantly, the quiet and peacefulness of the area. Resorts and residential developments will destroy the fishing and camping oppurtunities this area provides to local residents.

We now outline arguments satisfying requirements of section four, chapter 205, Hawaii Revised Statutes and Rules, State Land Use Commission. Within the coming week and within coming days we will submit mor arguments and evidence supporting this petition. Petitioners ask the Land Use Commission to consider this petition with the supporting evidence and arguments. We argue, in compliance with Rule 2-31, State Land Use District Regulations, that:

A) The subject property is needed for a use other than that for which the district in which it is located,
B) The land is usable and adaptable for the proposed use,
C) Conditions and trends of development have so changed since adoption of the present classification, that the proposed redistricting is reasonable.

A) This land must be redistricted to secure and protect our welfare and lifestyles, and to insure needed and orderly development of our choices for Lanai island. This land is needed. to prevent the devastation of our welfare and lifestyle, to insure needed and orderly development for the people of Lanai, and to protect our open spaces and recreational uses of the land.

Presentlly Lanai is a plantation community of approximately 2,200 people with an average annual family income of about $8,000. We may not be financially wealthy, but we are immensely rich in a rural lifestyle and an unspoiled environment.

Tourism and second-home developments will only jeopardize our way of life by tremendously increasing land values and consequently creating higher property taxes and housing costs thus placing a heavier burden on already low income families.

The resort industry and the people it brings will compete with local residents for recreational oppurtunities such as hunting, fishing, camping, hiking, and swimming and picnicking-recreational activities local people have always enjoyed and which are integral parts of our lifestyle. The influx of visitors and outside residents will lessen the quality of these recreational oppurtunities, thus lowering the quality and character of the local peoples' way of life.

Past experiences with the impact of large masses of outsiders associated with the resort industry and second-home developments show that local families of rural communities are put under tremendous social strains. Increasing divorce rates, separations,desertions, runaway children and an increased crime rate occur. This can be seen in Kailua-Kona, Lahaina and Kaanapali. Can the prospects for Lanai be much different if the Lanai Company development scheme is left to be implemented? Local families will be further burdened with the social ills attributed to urban growth.

Further, past experience has shown that the best jobs in the tourist industry go to outsiders, not local people. Generally, the jobs local people do get are the most menial, low paying, require the least amount of training, and are nonpersonal because the local people may lack communication skills required by the industry.

The resort and second-home development will inflate the already high cost of living. Second homes bring little to the local economy. Tourists will be agreeable to higher prices because of their short term demand and owners of second homes will have higher incomes to support the higher costs while local people will remain relatively constant in their purchasing power.

In addition, urban growth will harm and destroy the natural beauty, the open spaces, the quiet and gentle charm of our rural community. No price can be put on these precious resources that can never be replaced once taken away.

B) Clearly the land is usable and adaptable for the proposed uses we are advocating. The uses we propose are merely the present uses of the land. During recent times this land has been used for recreation and left as open space.

C) Conditions and trends of development have so changed since the adoption of the existing classification that the proposed conservation and agriculture classification is reasonable. Todays rising population, energy problem, high interest rates, runaway inflation, both national and international shortages of food and mineral resources, and the increasing importance of the State's diversified agriculture program, make the proposed redistricting reasonable and rational.

Proper planning requires the consideration of these situations for they constitute constraints on planning where we are to go regarding the construction of a viable future for Lanai and its people. The argument to be presented here will maintain that the Lanai Company's plan and the development of a viable agricultural base (alternative to pineaple) are mutually exclusive.

The argument for agriculture is basic. There is an ever increasing demand for food worldwide. This demand has approached crisis proportions in the light of the fact that millions are dying of malnutrition every year, the droughts in the grain-producing American Mid-west and Sub- Saharan Africa, the ever-increasing cost of food. It is common knowledge that our energy importation is being paid for in food exportation. Our energy needs are increasing at an exponential rate requiring greater dependence on fuel importation, while food production has nearly peaked, if it hasn't already. What then is the answer to this predicament? Rather than addressing itself to participating in the alleviation of this problem the plan will intensify the problem. Not only will the development require massive commitment of energy and resources in the constructing and the maintenance of the resort and second-home commuter transportation needs but there will be no additional increase in food production.

Lip-service can be given to the increase in agricultural lands and the maintenance of lands currently under pineapple cultivation. Agriculture is also energy intensive in its transportation, mechanization and fertilizer needs. Agriculture is the manifestation of a particular potential of land. It becomes an academic exercise to label land agriculture if the resources are not available to utilize its agricultural potential.

Lanai's water supply should be looked at in this context. Of all the constraints to development water is probably the most obvious. According to the Lanai Company Plan water appears to be a critical resource. Pineapple presently requires one-half to one billion gallons a year. The development will require an additional one billion gallons a year. The total requirement for pineapple and the developments call for a water supply of 1½-2 billion gallons a year. Their studies as submitted to the Land Use Commission show a total potential of only 1.3 billion gallons a year, a significant deficit of 200-700 million gallons per year. This tends to put a careful balance between pineapple and the developments in their competition for water. If pineapple phases out, and since pineapple requires a relatively small water supply in comparison to other crops, won't the water commitment to the other developments rule out the possibility of finding an agricultural alternative for the 15,000 acres of cultivable pineapple lands?

Furthermore, return of this land to its past districting, agriculture and conservation, will not adversely affect the surrounding area.

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Supporting evidence to "Petition for Amendment Of Certain District Boundaries On Lanai Island"

LANAI REDISTRICTING PETITION

The preservation and conservation of recreational and open space areas on Lanai are essential to the welfare, health, and quality of life that Lanai people enjoy. These natural resources, of great benefit to the people of Lanai, are threatened by hotels, second homes, and a rapidly increasing population.

With the hotels and second homes planned by the Lanai Company will come tourists and new residents - more people to use and experience the natural resources of Lanai such as Hulopoe beach and Naha. These people will overcrowd Lanai. Over twelve thousand new residents will be added to Lanai's present population of about two thousand-five hundred. Already, Lanai residents experience discomfort from the numbers of people at Hulopoe beach.

Several State plans have recognized the problem of too many visitors and new residents. The Udall Open Space Plan says "Hawaii should be first and foremost a homeland for its permanent residents; their environmental needs must be paramount in all decisions about the future. Conversely, the needs of the tourism industry in Hawaii must be adapted to -- and not detract from -- the indigenous amenities of Hawaii." (from page nine). The needs of Lanai people must come before the proposed hotels for Lanai. A primary environmental need is the protection of Manele and especially Hulopoe beach. The resort planned for Manele will bring new people crowding Hulopoe beach and all of Manele. Additionally, the Open Space Study says that "Since spaciousness, cleanliness, and natural beauty are among Hawaii's prime assets, the government should give highest priority to enhancing these amenities." (from page ten). Manele and other similar places need protection from an onslaught of tourists and second home residents. Furthermore, the Hawaii Tourism Impact Plan has found need to protect shoreline areas (page 151).

The State Comprehensive Outdoor Recreation Plan (SCORP) recommends "...mechanisms which will protect recreation areas from enroachment by incompatible uses which limit access or diminish user enjoyment." (page 133). And the SCORP recognizes that State and County goals and objectives indicate a need for "...conservation of the State's natural historic, and scenic resources." (page xii). Yet, Lanai's prime beach, swimming, and camping resource - Manele - is planned for development for the benefit of tourism at the expense of local people. Lanai has a great need for conserving its natural, recreational, scenic, and historic resources.

The proposed redistricting will protect the recreational oppurtunites and open space Lanai people enjoy. These State plans help express and reinforce the need for spacious and clean recreation and open space areas.

LANAI REDISTRICTING PETITION

The present districting of Lanai offers a large land speculation development of dubious benefit to the people of Lanai. The present Lanai plan calls for thousands of acres to be sold as country homes, ranchettes, and second homes. Petitioners feel that the rising land prices, increasing housing costs, and social-environmental impact due to the land speculation will harm the quality of life Lanai people now enjoy.

The State Tourism Impact Plan recognizes that the large numbers of lots in a development indicate a second home and retirement home market primarily directed to non-residents (from page 31). Additionally, the Plan sees:

> One important characteristic of the residential development planned is that many developers will be selling lots rather than housing units. This will especially be true of the detached second home residential uses projected on large acreages in many of the projects. Such sale of improved land on a large scale is indicative of the role that speculation will play in the development of many projects. (from page 32)

Furthermore, the Plan implies that resort projects like the Lanai Company's plan are for speculation (from page 32). The magnitude of the development offers an excellent speculation setting. Lastly, Chinn Ho has said (in an interview with "Hawaii Business" magazine, April, 1974), when talking about neighbor island investment oppurtunities:

> It would take a situation where we could get enough land around the actual resort site to take advantage of the appreciation realized by surrounding land when someone puts in a hotel and other facilities.

The petitioner clearly sees the Lanai plan to be a land speculation scheme not for the benefit of Lanai people. The vast acreages for low density residences to be sold as undeveloped lots plainly show the speculative nature of the development. Petitioners see no reason for the land to be speculated upon. The proposed redistricting will remove those immense acreages from that speculation-dvelopment not needed by Lanai people.

Several State plans recognize that speculation raises the price of land and housing thus intensifying the State's housing problems. The Open Space Study notes that:

> The speculative nature of these land sale developments will create sarious problems for the future housing market on the Neighbor Islands. The sale and resale of land on a speculative basis will cause the price of land to escalate rapidly. Thus, when homes are actually constructed in response to the needs of the local populace,. the inflated price of the land will have the effect of pushing up the total cost of housing. (from page 39)

And, The State Tourism Impact Plan sees that large land sales are intended for the second home and retirment home markets, primarily for people rich enough to build a home (page 31). It seems clear that the cost of housing will increase on Lanai (as well as the cost of land) and thus Lanai people will suffer from the increased prices. The proposed redistricting will stop the speculation-development and would provide the oppurtunity for better planning of Lanai island.

Water has always been scarce on the Island of Lanai. In H. T. Stearn's classic 1940 survey of the island's water resources, the dryness of the island is stressed throughout. He notes that the 3000 plus natives , " prior to 1778 according to Emory , depended chiefly on dew collected on oiled tapas or whipped from heavy shrubbery. Water that accumulated in natural depressions was husbanded carefully."

Rainfall, like on most of the subtropical islands of the Hawaiian chain, is very uneven and is sparser than on most other islands, because Lanai lies on the orographic rain shadow of West Maui & East Molokai. Annual rainfall ranges from a dry (7 inches) 17 cm on the coast to a moderate (38 inches) 96 cm. at the summit of Lanaihale. From the standpoint of water management, the paucity of water is complicated by the fact that, as Thomas Gray first put it, it never rains, but it pours. As Stearns points out, "Heavy downpours during a single kona storm commonly account for a considerable part of the annual rainfall, and in some of the arid sections, a single rain may contribute as much as 80 percent of the annual total." (emphasis mine) Needless to say, this aggravates the already difficult problem of water supply. In addition, rainfall exhibits severe seasonal and annual fluctuations. Annual rainfall at Keomuku varied between (1.7 & 33. inches) 4.4 * 83 cm over a 17 year period.

Shallow dug wells exist along the coast topping the shallow brackish basal lens of low level ground water. The geomorphology of the island requires that they be placed so close to the ocean that the chloride content of the water is too high for human consumption because of tidal mixing effects in the basal lens. Estimates of the chloride count range from 600 to 2100 ppm. (The State Health Dept. places an oxygen limit of 250 ppm of chloride for drinking water, though several local families have grown up with well water rated above this.)

Basal ground water resources are neither plentiful nor of particularly good quality on Lanai. The water table is shallow and according to Stearn's resistivity survey, it only rises 2.04 meters in 7.2 kilometers (6.7 feet in 4.5 miles.)

High level acquifer ground water accounts for the bast bulk of Lanai's currently developed potable resources. A series of collection tunnels, top shafts, and collections at natural seeps provide Lanai City and Dole Company with an adequate, if not a plentiful, supply of quality water. Currently developed water for the entire island was estimated by R. A. Moore Associates recently to be 850 million gallons/year (3.22 million kiloliters.) They also cite a figure of 1324 MG/year (5.02 M. kiloliters) as the "total potential on a sustained basis." The size of this figure and the ambiguity of the phrase "sustained annual yield" suggests that Moore & Associates are referring to the sum total volume of potentially recoverable water on a sustaining yield basis for the period of one calendar year. By this accounting, the winter downpours balance the summer droughts with the net result of a deceptively large figure for available sustained yield water. For planning purposes a figure of 365 x the year's minimum daily sustained yield flow should be used.

Towill Corporation, Moore's engineering consultants were contacted in order to clarify this situation. In the twenty-four hours available they failed to provide such clarification, and we are forced to assume, in the light of Stearn's data, that the potential sustained yield water figure of 1324 MG/year is deceptively large. Furthermore to quote annual figures on a "sustained basis" is a little absurd, given the extreme seasonal fluctuations of Lanai's rainfall. Gallons per week on a sustained basis throughout the seasonal cycle should be recorded and the lowest week's sustained yield (probably in July) should be the basis for planning.

The Molokai Water Resources Feasibility Study by Parsons Brinekerhoff estimates water usage for hotel purposes at 600 gallons per room per day. For example, a 1000 unit hotel would require approximately 220 MG/year. This is nearly 50% of the undeveloped water on the island.

Attempts to coat this development pill with diversified agriculture are absurd. Pineapple is one of the few crops that requires no irrigation in the dry Lanai fields. There simply isn't the water for both diversified agriculture and development.

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EXHIBIT A

Magazine articles in reference to food shortage and energy problem.

Food Production and the Energy Crisis

David Pimentel, L. E. Hurd, A. C. Bellotti, M. J. Forster, I. N. Oka, O. D. Sholes, R. J. Whitman

By 1975 the world population is expected to reach 4 billion humans (*1*). As it continues to grow, there is increasing concern about ways to prevent wholesale starvation (*2*). Concurrently, an energy crisis (due to shortages and high prices) is expected as finite reserves of fossil fuels are rapidly depleted (*3*, *4*). The energy crisis is expected to have a significant impact on food production technology in the United States and the "green revolution," because both systems of crop production depend upon large energy inputs.

Both the U.S. type of agriculture and the "green revolution" type of agriculture have been eminently successful in increasing crop yields through improved technology. The ratio of persons not on farms to each farm worker in the United States increased from 10 in 1930 to 48 persons in 1971 (*5*, *6*). This has lead to great social change as numbers of unemployed, untrained farm laborers migrated to our cities (*7*). In addition, the costs to the natural environment have been great, as is reflected in depleted soils, pollution, disruption of natural plant and animal populations, and natural resource shortages. One nonrenewable resource fast being depleted is fossil fuel—the most important element in the impressive yields and quality of agriculture in the United States. Energy is used in mechanized agricultural production for machinery, transport, irrigation, fertlizers, pesticides, and other management tools. Fossil fuel inputs have, in fact, become so integral and indispensable to modern agriculture that the anticipated energy crisis will have a significant impact upon food production in all parts of the world which have adopted or are adopting the Western system.

As agriculturalists, we feel that a careful analysis is needed to measure energy inputs in U.S. and green revolution style crop production techniques. Our approach is to select a single crop, corn (maize), which typifies the energy inputs for crops in general, and to make a detailed analysis of its production energy inputs. With the data on input and output for corn as a model, an examination is then made of energy needs for a world food supply that depends on modern energy intensive agriculture. Using corn as an example, we consider alternatives in crop production technology which might reduce energy inputs in food production. Other than recognizing the high costs of U.S. energy intensive agriculture, we make no effort to examine any of the projected economic, sociological, or political "trade-offs" in the United States or other countries when the energy crisis upsets the world community (*8*).

Energy Resources

As fossil fuel resources decline, the costs of obtaining fuels both from domestic and foreign sources will rapidly increase. If current use patterns continue, fuel costs are expected to double or triple in a decade (*4*) and to increase nearly fivefold by the turn of the century (*9*, *10*). When energy resources become expensive, significant changes in agriculture will take place.

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High energy use correlates closely with high gross national product (GN[illegible] (*11*). In 1970, the United States consumed a total of 1.6×10^{16} kilocalories, or more than one-third of the total world energy consumption (*3*) and 35 percent of the world's petroleum (*12*)—for only one-seventeenth of the world pe[illegible]n. This country's energy use has doubled during the past 20 years. In some types of agricultural production, the rate of energy use has increased more than threefold during the same period.

Hammond (*3*) reported that about 96 percent of the United States' energy "comes from fossil fuels: petroleum, 43 percent, mostly for transportation; natural gas, 33 percent; and coal, 20 percent. Hydroelectric energy accounts for about 3 percent of present production, and nuclear energy for about 1 percent." Peak petroleum consumption is expected to occur by the end of the century (*13*). Hammond (*3*) estimated that, if the United States were to use petroleum exclusively to provide all of its energy needs at present rates of consumption, the known, recoverable U.S. reserves would be depleted in only 5 years.

As was mentioned, crop production depends heavily on energy inputs just to produce the raw product. In addition, large amounts of energy are consumed as the raw products are transported to centers to be processed, frozen, canned, dehydrated, ground, baked, and so forth. Farmers process little of their own food, being dependent themselves upon the food proc[illegible]sing, wholesaling, and retailing industries. They also depend [illegible]tude of other industries to supply machinery, fertilizers, pesticides, improved crop varieties, and other supplies. For every farm worker, it is estimated there are two farm-support workers (*14*). Thus, about 20 percent of the nation's work force and industries are involved in supplying food (*14*). The farm-support and food processing industries may use more energy than farming itself, further emphasizing the dependence of our food system upon energy. The oft-quoted statistic that one farm worker feeds 48 persons (*5*) is misleading because the farmer depends on a complex of support industries.

Table 1. Average energy inputs in corn production during different years (all figures per acre).

Inputs	1945	1950	1954	1959	1964	1970
Labor*	23	18	17	14	11	9
Machinery (kcal × 10³)†	180	250	300	350	420	420
Gasoline (gallons)‡	15	17	19	20	21	22
Nitrogen (pounds)§	7	15	27	41	58	112
Phosphorus (pounds)§	7	10	12	16	18	31
Potassium (pounds)§	5	10	18	30	29	60
Seeds for planting (bushels)‖	0.17	0.20	0.25	0.30	0.33	0.33
Irrigation (kcal × 10³)¶	19	23	27	31	34	34
Insecticides (pounds)#	0	0.10	0.30	0.70	1.00	1.00
Herbicides (pounds)**	0	0.05	0.10	0.25	0.38	1.00
Drying (kcal × 10³)††	10	30	60	100	120	120
Electricity (kcal × 10³)‡‡	32	54	100	140	203	310
Transportation (kcal × 10³)§§	20	30	45	60	70	70
Corn yields (bushel)‖‖	34	38	41	54	68	81

* Mean hours of labor per crop acre in United States (*6, 25*). † An estimate of the energy inputs for the construction and repair of tractors, trucks, and other farm machinery was obtained from the data of Berry and Fels (*63*), who calculated that about 31,968,000 kcal of energy was necessary to construct an average automobile weighing about 3400 pounds. In our calculations we assumed that 244,555,000 kcal (an equivalent of 13 tons of machinery) were used for the production of all machinery (tractors, trucks, and miscellaneous) to farm 62 acres of corn. This machinery was assumed to function for 10 years. Repairs were assumed to be 6 percent of total machinery production or about 15,000,000 kcal. Hence, a conservative estimate for the production and repair of farm machinery per corn acre per year for 1970 was 420,000 kcal. A high for the number of tractors and other farm machinery on farms was reached in 1964 and continues (*64, 65*). The number of tractors and other types of machinery in 1945 were about half what they are now. ‡ DeGraff and Washbon (*66*) reported that corn production required about 15 gallons of fuel per acre for tractor use—intermediate between fruit and small grain production. Because corn appeared to be intermediate, the estimated mean fuel (gallons) burned in farm machinery per harvested acre was based on U.S. Department of Agriculture (*22, 64*) and U.S. Bureau of the Census (*65*) data. § Fertilizers (N, P, K) applied to corn are based on USDA (*25, 26, 61, 62*) estimates. ‖ During 1970, relatively dense corn planting required about one-third of a bushel of corn (25,000 kernels or 34,000 kcal) per acre; the less dense plantings in 1945 were estimated to use about one-sixth of a bushel of seed. Because hybrid seed has to be produced with special care, the input for 1970 was estimated to be 68,000 kcal. ¶ Only about 3.8 percent of the corn grain acres in the United States were irrigated in 1964 (*67*), and this is not expected to change much in the near future (*68*). Although a small percentage, irrigation is costly in terms of energy demand. On the basis of the data of Epp (*69*) and Thorfinnson *et al.* (*70*), an estimated 905,600 kcal is required to irrigate an acre of corn with an acre-foot of water for one season. Higher energy costs for irrigation water are given by *The Report on the World Food Problem* (*2*). Since only 3.8 percent of the corn acres are irrigated (1964–1970), it was estimated that only 34,000 kcal were used per acre for corn irrigation. The percentage of acres irrigated in 1945 was based on trends in irrigated acres in agriculture (*55, 67*). # Estimates of insecticides applied per acre of corn are based on the fact that little or no insecticide was used on corn in 1945, and this reached a high in 1964 (*28, 51*). ** Estimates of herbicides applied per acre of corn are based on the fact that little or no herbicides were used on corn in 1945 and that this use continues to increase (*28, 51*). †† When it is dried for storage to reduce the moisture from about 26.5 percent to 13 percent, about 408,204 kcal are needed to dry busheds (*71*). About 30 percent of the corn was estimated to have been dried in 1970 as compared to an estimated 10 percent in 1945. ‡‡ Agriculture consumed about 2.5 percent of all electricity produced in 1970 (*24*) and an estimated 424.2 trillion British thermal units of fossil fuel were used to produce this power (*72*); on croplands this divides to 310,000 kcal per acre for 1970 (*6, 51*). The fuel used to produce the electrical energy for earlier periods was estimated from data reported in *Statistical Abstracts* (*73*). §§ Estimates of the number of calories burned to transport machinery and supplies to corn acres and to transport corn to the site of use is based on data from U.S. Department of Commerce (*74*), U.S. Bureau of the Census (*65, 67, 72*), Interstate Commerce Commission (*75*), and U.S. Department of Transportation (*76*). For 1964 and 1970 this was estimated to be about 70,000 kcal per acre, it was about 20,000 kcal per acre in 1945. ‖‖ Corn yield is expressed as a mean of 3 years, 1 year previous and 1 year past (*55, 59, 60*).

Corn Production and Energy Inputs

To investigate the relationship of energy inputs to crop production, we selected corn for the following reasons. (i) Corn generally typifies the energy inputs in U.S. crop production for it is intermediate in energy inputs between the extremes of high energy-demand fruit production and low energy-demand tame hay and small grain production. (ii) Corn is one of the leading grain crops in the United States and the world. (iii) More data are available on corn than on other crops. Concerning corn data, we have had to rely heavily on Department of Agriculture survey data and estimates provided by various other studies. Although the best available, some of these data have inherent limitations. Despite these shortcomings, this analysis provides a valuable perspective concerning the large energy inputs in U.S. agriculture.

Corn, the most important grain crop grown in the United States, ranks third in world production of food crops (*15*). In terms of world cereal grains, it ranks second to wheat. During 1971, world corn production on 279 million acres was 308 million metric tons (*16*).

Corn yield per acre (1 acre = 0.405 hectare) in the United States has increased significantly from 1909 to 1971 (Fig. 1). During 1909, the corn yield averaged 26 bushels per acre, and during 1971 it averaged 87 bushels per acre. A sharp rise in production per acre started about 1950—a time when many changes, including the planting of hybrid corn, were taking place in corn culture (*17–19*). The planting of hybrid corn probably accounts for

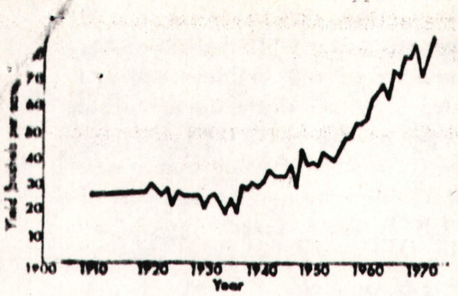

Fig. 1. Corn production (bushels per acre) in the United States from 1909 to 1971 (55, 59, 60).

20 to 40 percent of the increased corn yields since the 1940's with energy resource inputs accounting for 60 to 80 percent (17, 20, 21). Hybrid corn and energy inputs toward increased yields overlap because corn plants are often selected for characteristics that make the plant perform well under specific environmental conditions as, for example, with high fertilizer inputs. Without the appropriate genetic background, the corn plant will not respond to the fertilizer inputs and, of course, the corn plant cannot respond if fertilizer is absent.

While corn yields increased about 240 percent from 1945 to 1970, the labor input per acre decreased more than 60 percent (Table 1). Intense mechanization reduced the labor input and, in part, made possible the increased corn yield.

Machinery in agriculture has increased significantly during the past 20 years; the mean rate of horsepower per farm worker has increased from 10 in 1950 to 47 in 1971 (5). The number of tractors increased (88 percent) from 2.4 million in 1945 to 4.5 million in 1972 (6, 22). Concurrently, the rated horsepower of these tractors increased 2.6-fold from 18.0 to 46.6 horsepower (6, 22). The mean number of acres farmed per tractor was 62 in 1963 (22). In our estimates we assumed that tractors and other machinery were used to farm 62 acres and assumed to function for 10 years (Table 1).

Fuel consumption for all farm machinery rose from slightly more than 3.3 billion gallons (1 gallon = 3.8 liters) in 1940 to about 7.6 billion gallons in 1969 (22, 65). For total U.S. corn production, fuel consumption for all machinery rose from an estimated 15 gallons per acre in 1945 to about 22 gallons per acre in 1970 (Table 1). Indeed, farming uses more petroleum than any other single industry (24).

The use of fertilizer in corn production has been rising steadily since 1945 (Fig. 2). An estimated 7 pounds (1 pound = 0.4 kilogram) of nitrogen, 7 pounds of phosphorus, and 5 pounds of potassium were applied per acre to the acres fertilized in 1945 (25). By 1970 the application of fertilizers had risen to 112 pounds of nitrogen, 31 pounds of phosphorus, and 60 pounds of potassium per acre (26). The increase in nitrogen alone has been about 16-fold.

Other inputs in corn production include seeds, irrigation, and pesticides (Table 1). The use of pesticides in corn has been increasing rapidly during the past 20 years and this parallels the general increase in pesticide use in the United States (27) (Table 1).

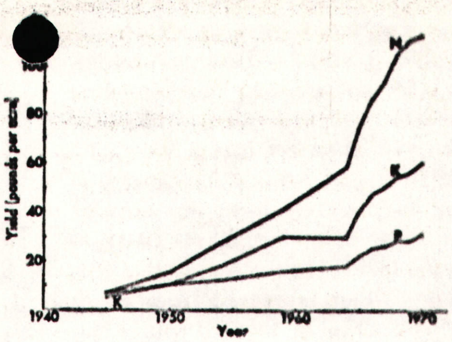

Fig. 2. Fertilizer (nitrogen, phosphorus, and potassium) applied per acre in corn production (25, 26, 61, 62).

About 41 percent of all herbicides and 17 percent of all insecticides used in agriculture are applied to corn (28).

Hybrid corn that is currently harvested has a higher moisture content because the newer varieties have growing seasons which extend further into the fall when drying conditions are poor (19). Moisture content above 13 percent (the maximum suitable for long-term storage) causes spoilage, and a drying process is used to reduce moisture (Table 1).

Agriculture consumed about 2.5 percent of all electricity produced (Table 1). The energy input for transportation is an important feature of modern intensive agriculture (Table 1). Machinery, pesticides, seeds, gasoline, and other supplies must be transported to the farm. Then the corn harvest must be transported to the place of use for animal feed or processing.

To gain an idea of the changes occurring over a period of time in corn production energy inputs, the years

Table 2. Energy inputs (kilocalories) in corn production.

Input	1945	1950	1954	1959	1964	1970
Labor*	12,500	9,800	9,300	7,600	6,000	4,900
Machinery†	180,000	250,000	300,000	350,000	420,000	420,000
Gasoline‡	543,400	615,800	688,300	724,500	760,700	797,000
Nitrogen§	58,800	126,000	226,800	344,400	487,200	940,800
Phosphorus‖	10,600	15,200	18,200	24,300	27,400	47,100
Potassium¶	5,200	10,500	50,400	60,400	68,000	68,000
Seeds for planting#	34,000	40,400	18,900	36,500	30,400	[illegible]
Irrigation†	19,000	23,000	27,000	31,000	34,000	34,000
Insecticides**	0	1,100	3,300	7,700	11,000	11,000
Herbicides††	0	600	1,100	2,800	4,200	11,000
Drying†	10,000	30,000	60,000	100,000	120,000	120,000
Electricity†	32,000	54,000	100,000	140,000	203,000	310,000
Transportation†	20,000	30,000	45,000	60,000	70,000	70,000
Total inputs	925,500	1,206,400	1,548,300	1,889,200	2,241,900	2,896,800
Corn yield (output)‡‡	3,427,200	3,830,400	4,132,800	5,443,200	6,854,400	8,164,800
Kcal return/input kcal	3.70	3.18	2.67	2.88	3.06	2.82

* It is assumed that a farm laborer consumes 21,770 kcal per week and works a 40-hour week. For 1970: (9 hours/40 hours) × 21,770 kcal = 4,900 kcal. † See Table 1. ‡ Gasoline, 1 gallon = 36,225 kcal (77). § Nitrogen, 1 pound = 8,400 kcal, including production and processing (78). ‖ Phosphorus, 1 pound = 1,520 kcal, including mining and processing (79). ¶ Potassium, 1 pound = 1,050 kcal, including mining and processing (79). # Corn seed, 1 pound = 1,800 kcal (33). This energy input was doubled because of the effort employed in producing hybrid seed corn. ** Insecticides, 1 pound = 11,000 kcal including production and processing (similar to herbicide; see ††). †† Herbicides, 1 pound = 11,000 kcal including production and processing (31). ‡‡ Each pound of corn was assumed to contain 1,800 kcal (33) and a bushel of corn was considered to be 56 pounds.

[illegible], 1954, 1959, 1964, and 1970 were selected for a detailed analysis (Tables 1 and 2). Exact 5-year intervals were not selected because more complete data were available on these specific years than on others.

In 1970 about 2.9 million kcal was used by farmers to raise an acre of corn (equivalent to 80 gallons of gasoline) (Table 2). From 1945 to 1970, mean corn yields increased from about 34 bushels per acre to 81 bushels per acre (2.4-fold); however, mean energy inputs increased from 0.9 million kcal to 2.9 million kcal (3.1-fold) (Table 2). Hence, the yield in corn calories decreased from 3.7 kcal per one fuel kilocalorie input in 1945 to a yield of about 2.8 kcal from the period of 1954 to 1970, a 24 percent decrease.

The 2.9 million kcal input of fossil fuel represents a small portion of the energy input when compared with the solar energy input. During the growing season, about 2043 million kcal reaches a 1-acre cornfield; about 1.26 percent of this is converted into corn and about 0.4 percent in corn grain (at 100 bushels per acre) itself (*29*). The 1.26 percent represents about 26.6 million kcal. Hence, when solar energy input is included, man's 2.9-million-kcal fossil fuel input represents about 11 percent of the total energy input in corn production. The important point is that the supply of solar energy is unlimited in time, whereas fossil fuel supply is finite.

The trends in energy inputs and corn yields confirm several agricultural evaluations which conclude that the impressive agricultural production in the United States has been gained through large inputs of fossil energy (*8*, *30*).

Alternatives

Some alternatives may be needed to reduce energy inputs in agricultural food production when conventional energy resources become in short supply and costs soar. Some of the practical alternatives which might be employed in corn and other crop production are reviewed below.

The energy input from farm labor in corn production is the smallest of all inputs, only 4,900 kcal (Table 2). Increasing some labor inputs can significantly reduce some energy inputs. For example, one application of herbicide to corn requires about 18,000 kcal/acre if applied by tractor and sprayer (*31*) but less than 300 kcal if applied

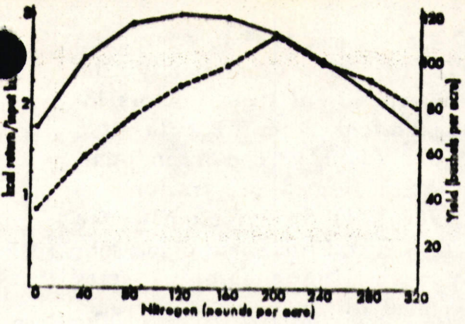

Fig. 3. Corn yields (bushels per acre, dashed line) with varying amounts of nitrogen (phosphorus = 34 pounds per acre) applied per acre (*45*). The kilocalorie return per kilocalorie of input (solid line) was calculated from the data of Munson and Doll (*45*) and from the 1970 input data in Tables 1 and 2.

by hand sprayer. Although 1/60 as much energy is used, the labor cost of hand application today is about four times that of the tractor application. Hand application might become economically profitable when fuel costs increase and if herbicides are used in spot treatment only.

Machinery and gasoline comprise a large energy input in corn production (Table 2). A viable alternative for reducing this fuel use would be to use machinery precisely scaled for its job and operate it at efficient speeds (*32*). Some of the extremely large tractors and other machinery will do more work per unit time, but this efficiency is offset by greater fuel requirements during operation. In addition, increasing the number of acres tended by a tractor or other machinery (currently about 62 acres per tractor) would help reduce this input. Horses and mules are not satisfactory substitutes for machinery because of the large quantity of energy they consume in feed (*33*).

The single largest input in corn production is fertilizer; nitrogen requires the largest quantity of energy to produce (Tables 1 and 2). A potential fertilizer source is the small percentage of livestock manure that is not now being used in crop production.

We mentioned that chemical fertilizer is applied to corn at a rate of 112 pounds of nitrogen, 31 pounds of phosphorus, and 60 pounds of potassium (Table 1). A like amount of nitrogen is available from manure produced during one year by either 1 dairy cow, 2 young fattening beef cattle, 9 hogs, or 84 chickens (*34*). In addition to the nutrients manure adds to the soil, it adds organic matter which increases the number of beneficial bacteria and fungi in the soil, makes plowing easier, improves the waterholding and percolation capacity of soil, reduces soil erosion, and improves the ratio of carbon to nitrogen in the soil (*35*).

The major costs of using manure for crop production are hauling and spreading. Hauling and spreading manure within a radius of ½ to 1 mile (1 mile = 1.6 kilometers) is estimated to require 1.1 gallons of gasoline per ton [calculated from data of Linton (*36*)]. If the average manure application is 10 tons (production by 1 cow for 1 year) per acre, an estimated 398,475 kcal (11 gallons of gasoline) per acre is necessary to apply the manure and hence to fertilize corn with manure. Producing chemical fertilizer (112 pounds of nitrogen, 31 pounds of phosphorus, 60 pounds of potassium) for 1 acre requires a total of 1,415,200 kcal (Table 2). One gallon of gasoline is used for tractor application, therefore a total of 1,451,425 kcal for chemical fertilizer application is used. Hence, if manure were substituted for chemical fertilizer, the savings in energy would be a substantial 1.1 million kcal per acre.

Current U.S. livestock manure production is estimated to be 1.7 billion tons per year, over 50 percent of which is produced in feedlots and confinement rearing situations (*37*). If 20 percent of the manure produced in feedlots and confinement rearing situations (0.17 billion tons) were available for use in corn production, 17.0 million acres of corn could be fertilized at an average manure application rate of 10 tons per acre. The above acreage would be 30 percent of the 1970 harvested grain corn acreage (*38*). In addition to saving valuable fuel energy, applying this manure to crop land would effectively recycle these animal wastes (*39*).

If some of the livestock manure from feedlots and confinement rearing situations is to be used, then these livestock production facilities would have to be moved closer to cropland where the manure is to be used. Redistributing livestock facilities would itself require a careful analysis of associated costs.

Nitrogen fertilizer inputs can also be reduced by planting legumes or other alternate crops in rotation with corn. For example, planting sweet clover in the fall and plowing it under 1 year later will add about 150 pounds of nitrogen per acre to the soil (*40*). Rotating corn with a legume would also effectively control the corn rootworm (*41*), would reduce corn disease *lems* (*42*), and would reduce weed *problems* (*43*).

When rotations are not feasible, it is possible to plant legumes between corn rows in late August and to plow this green manure under in early spring. In the northeast, Sprague (*44*) reports that seeding corn acreage to winter vetch in late August and plowing the vetch under in late April yielded about 133 pounds of nitrogen per acre. A cover crop also protects the soil from wind and water erosion during the winter and has the same advantages as manure in adding organic matter to the soil.

The energy cost of seeding a legume, we estimate, would require about 90,000 kcal/acre (fuel and seeds). For the commercial production of 133 pounds of nitrogen, 1.53 million kcal are needed; thus the energy saved by planting a legume for green manure would be substantial or 1.5 million kcal/acre. Hence, green manure offers a greater saving than livestock manure.

With fertilizer and other alternative inputs, a measure should be made to determine the maximum benefit per input in combination with all other inputs. In an investigation of fertilizer inputs in Iowa, Munson and Doll (*45*) reported that with 34 pounds of phosphorus per acre and 200 pounds of nitrogen per acre, they calculated mean corn yields of about 101 bushels per acre with all other inputs held constant (Fig. 3). Combining most of the 1970 energy input data from Tables 1 and 2 with the nitrogen, phosphorus, and corn yield data of Munson and Doll, we calculated the kilocalorie return per kilocalories input (Fig. 3). Maximum return was 3.0 kcal for 1 kcal input at 120 pounds of nitrogen per acre. A return of 2.8 for 1 was estimated for 1970 with the use of 112 pounds of nitrogen and 31 pounds of phosphorus per acre (Table 2). On the basis of only nitrogen inputs combined with the other inputs listed for 1970, it would appear that 112 pounds of nitrogen per acre provide nearly a maximum kilocalorie return per input kilocalorie.

Weeds can be controlled effectively and economically by either mechanical cultivation, herbicides, or a combination (*46*). On the basis of the energy expenditure, herbicidal weed control requires more energy than mechanical cultivation. For example, using 2 pounds of preemergence and 2 pounds of postemergence herbicides per acre requires a total energy input of about 80,225 kcal/acre (11,000 kcal per pound of herbicide plus 1 gallon gasoline for two applications) (*31*). The use of three cultivations (rotary hoe twice) would require an estimated 2 gallons of gasoline or 72,450 kcal/acre. Although the saving is not as large as some, alternatives do exist for reducing energy inputs for weed control.

With postemergence herbicides under certain conditions, it might be possible to spot-treat and therefore reduce the total quantity of herbicide used. To be done effectively, more labor would be necessary. In general, today's high labor and low energy costs would prohibit this, but with high energy costs, spot treatments could become economically feasible.

Rotating corn with other crops such as legumes and small grains may significantly reduce weed problems (*47*) and, therefore, reduce energy inputs for weed control.

Minimum tillage may also offer some opportunity to reduce energy inputs in plowing and disking, but this must be balanced against increased pest problems. A more complete analysis would be necessary to determine the precise costs and benefits of this alternative.

The protein content of corn has changed little since 1910, averaging about 9 percent (*48*, *49*). However, the protein content of corn could be increased by selection to 12 to 15 percent (*50*). The value of increasing the quantity of protein in corn by even 1 percent is clear when it is calculated that this would reduce the need for 2 million tons of soybean meal in U.S. mixed feeds (*48*). Some increased energy inputs, such as nitrogen, would be necessary for cultivars of high protein corn, but the benefits would more than offset the costs.

Breeding corn for insect, disease, and bird resistance would in itself reduce the energy inputs of pesticides. At the same time this would reduce problems from pesticide pollution. Also, less energy would be needed for corn production if new corn varieties could be developed for faster maturity, reduced moisture content, greater water efficiency, and improved fertilizer response.

While only a small percentage (3.8 percent) of corn acres is irrigated, transporting water is an operation that demands lots of energy. The only alternative to reduce irrigation costs is to raise corn in regions where irrigation is seldom necessary. In the future, high energy costs may automatically reduce the percentage of corn acres irrigated.

The energy input for transportation of equipment and supplies to and from the farm is considerable. A real opportunity to reduce this input would be to move more of the materials and goods by train than by truck, because trains are significantly more efficient for transport (*8*).

Most of the alternatives mentioned would probably not fit easily into current corn management programs; however, when energy becomes costly, some or all of the alternatives may become practical and necessary. Furthermore, it should be emphasized that in some cases the partial use of one or more alternatives may prove to be the most economical procedure. By employing combinations of several of these alternatives, we estimate that it would be possible to reduce energy inputs by about a half and still maintain present yields. The economic feasibility of this depends of course upon many factors—including future energy costs.

World Food Supply

The shortages of food supplies in some nations (*2*) have prompted the United States to develop various international agricultural programs to aid in the "green revolution." Green revolution agricultural technology requires high energy inputs especially in fertilizers, pesticides, and hybrid seeds. Obviously, as energy shortages occur and costs increase, the success of the green revolution will be affected. For this reason, the problems of food production and energy demand on a worldwide basis are briefly examined.

In estimating the fuel energy needs to feed 4 billion humans, modern production technology similar to U.S. and green revolution agriculture is assumed. Energy data on U.S. corn will be used since it approximates average inputs and outputs in modern crop production. Our analysis indicated that about 2.9 million kilocalories of energy was used to raise an acre of corn in 1970—the equivalent of 80 gallons (2.5 barrels) of gasoline per acre (Table 2).

An estimated 330 million acres were planted in crops in 1970 (excluding cotton and tobacco) (*6*, *51*). With about 200 million people in the United States, this averages about 1.7 acres per capita; but since about 20 percent of our crops is exported, the estimated acreage is about 1.4 acres per capita. In terms of fuel per person for food, employing modern intensive agricul-

, this is the equivalent of 112 gallons of gasoline per person (80 gallons per acre × 1.4 acres per person = 112 gallons). Using U.S. agricultural technology to feed a world population of 4 billion on an average U.S. diet for 1 year would require the energy equivalent of 488 billion gallons of fuel.

To gain some idea about what the energy needs would be for different diets if U.S. agricultural technology were employed, an estimate is made of how long it would take to deplete the known and potential world reserves of petroleum. The known reserves have been estimated to be 546 billion barrels (*52*). If we assume that 76 percent of raw petroleum can be converted into fuel (*52*), this would equal a usable reserve of 415 billion barrels. *If petroleum* were the only source of energy and if we used *all* petroleum reserves solely to feed the world population, the 415-billion-barrel reserve would last a mere 29 years [(415 billion barrels/448 billion gallons)/(31.5 gallons per barrel = 29 years)]. The estimate would be 107 years if all potential reserves (2000 billion barrels) (*53*) of petroleum were used for food production. However, if the world population were willing to eat nothing but corn grain, potential petroleum reserves could feed a projected 10 billion humans for 448 years.

Contrary to popular belief, U.S. food production costs are high (*54*). Although only 16.6 percent of a person's total disposable mean income of $3595 in the United States was spent for food in 1970 (*5, 23*), the percentage is small only because U.S. per capita earnings are high. The 16.6 percent of U.S. per capita income of $3595 for food is $597. Since a third of food retail prices is production costs (*55*), it costs about $199 to produce $597 worth of food or 3110 kcal per person per day per year [including 66 g of animal protein and 18 g of animal fat (*2, 56*)]. This is the equivalent of 5280 plant kcal per person per day per year (assuming that 7 kcal of plant product is needed to produce 1 kcal of animal protein and fat with 1 g of animal protein = 4 kcal and 1 g of fat = 9 kcal). Thus, the cost for 1000 kcal of plant product is about $38.

In India about 77 percent of a person's income is spent for food with expenditures per capita averaging about $23 (includes marketing costs) per year (*2*). The caloric intake per person per day averages 2000 kcal, with animal protein being about 7 g per day and animal fats assumed to be 2 g (*2*). This is the equivalent of 2280 plant kcal per person per day per year. Thus the cost for 1000 plant kcal is about $10. Hence, the cost of producing 1000 plant kcal per day per year in India is significantly less than the $38 costs in the United States. This is in part due to the difference between nations in the plant crops used for food.

Conclusions

The principal raw material of modern U.S. agriculture is fossil fuel, whereas the labor input is relatively small (about 9 hours per crop acre). As agriculture is dependent upon fossil energy, crop production costs will also soar when fuel costs increase two- to fivefold. A return of 2.8 kcal of corn per 1 kcal of fuel input may then be uneconomical.

Green revolution agriculture also uses high energy crop production technology, especially with respect to fertilizers and pesticides. While one may not doubt the sincerity of the U.S. effort to share its agricultural technology so that the rest of the world can live and eat as it does, one must be realistic about the resources available to accomplish this mission. In the United States we are currently using an equivalent of 80 gallons of gasoline to produce an acre of corn. With fuel shortages and high prices to come, we wonder if many developing nations will be able to afford the technology of U.S. agriculture.

Problems have already occurred with green revolution crops, particularly problems related to pests (*57*). More critical problems are expected when there is a world energy crisis. A careful assessment should be made of the benefits, costs, and risks of high energy-demand green revolution agriculture in order to be certain that this program will not aggravate the already serious world food situation (*58*).

To reduce energy inputs, green revolution and U.S. agriculture might employ such alternatives as rotations and green manures to reduce the high energy demand of chemical fertilizers and pesticides. U.S. agriculture might also reduce energy expenditures by substituting some manpower currently displaced by mechanization.

While no one knows for certain what changes will have to be made, we can be sure that when conventional energy resources become scarce and expensive, the impact on agriculture as an industry and a way of life will be significant. This analysis is but a preliminary investigation of a significant agricultural problem that deserves careful attention and greater study before the energy situation becomes more critical.

References and Notes

1. National Academy of Sciences, *Rapid Population Growth*, I-II (Johns Hopkins Press, Baltimore, 1971).
2. President's Science Advisory Committee, *Report of the Panel on the World Food Supply*, I-III (The White House, Washington, D.C., 1967).
3. A. L. Hammond, *Science* **177**, 875 (1972).
4. P. H. Abelson, *ibid.* **178**, 355 (1972).
5. U.S. Department of Agriculture, *Misc. Publ.* No. 1063 (1972).
6. ———, *Stat. Bull.* No. 233 (1972).
7. T. L. Smith, *International Labour Review* **102**, 149 (1970).
8. L. Rocks and R. P. Runyon, *The Energy Crisis* (Crown, New York, 1972), pp. 12 and 131.
9. G. V. Day, *Futures* **4**, 331 (1972).
10. M. Slesser, *Report to Program on Policies for Science and Technology in Developing Nations* (Univ. of Strathclyde, Glasgow, 1972).
11. E. Cook, *Sci. Amer.* **225**, 135 (1971).
12. J. Darmstadter, P. D. Teitelbaum, J. G. Polach, *Energy in the World Economy* (Johns Hopkins Press, Baltimore, 1971).
13. P. E. Glaser, *Science* **162**, 857 (1968).
14. K. L. Robinson, personal communication.
15. Food and Agriculture Organization, United Nations, *Production Yearbook* **25**, 35 (1972).
16. ———, *Monthly Bull. Agr. Econ. Stat.* No. 20 (1971).
17. C. V. Griliches, *Econometrica* **25**, 501 (1957).
18. R. W. Allard, *Principles of Plant Breeding* (Wiley, New York, 1960), p. 265.
19. S. R. Aldrich and E. R. Leng, "Modern corn production," *Farm Quarterly* (1966), p. 296 and figure 150.
20. C. Grogan, personal communication.
21. H. L. Everett, personal communication.
22. U.S. Department of Agriculture, *Stat. Bull.* No. 344 (1964).
23. U.S. Department of Commerce, *Survey of Current Business* **52**, table 10 (1972).
24. *Committee on Agriculture, House of Representatives* (92nd Congress, 1971), p. 20.
25. U.S. Department of Agriculture, *Changes in Farm Production and Efficiency* (Agricultural Research Service, Washington, D.C., 1954).
26. ———, *Fertilizer Situation* (Economics Research Service, FS-1, 1971).
27. ———, *The Pesticide Review 1970* (Agricultural Stabilization and Conservation Service, Washington, D.C., 1971).
28. ———, *Agricultural Economics Report* No. 179 (Economics Research Service, 1970).
29. E. N. Transeau, *Ohio J. Sci.* **26**, 1 (1926).
30. P. Handler, *Biology and the Future of Man* (Oxford Univ. Press, New York, 1970), p. 462; H. T. Odum, *Environment, Power, and Society* (Wiley, New York, 1971), p. 115; R. A. Rappaport, *Sci. Amer.* **225**, 117 (1971); G. Borgström, *Hungry Planet* (Macmillan, New York, 1972), p. 513; K. E. F. Watt, *Principles of Environmental Science* (McGraw-Hill, New York, 1973), p. 216.
31. D. Pimentel, H. Mooney, L. Stickel, *Panel Report for Environmental Protection Agency*, in preparation.
32. W. H. Johnson and B. J. Lamp, *Principles, Equipment, and Systems for Corn Harvesting* (Agricultural Consulting Associates, Inc., Wooster, 1966), p. 95.
33. F. B. Morrison, *Feeds and Feeding* (Morrison, Ithaca, N.Y., 1946), pp. 50 and 429.
34. E. J. Benne, C. R. Hoglund, E. D. Longnecker, R. L. Cook, *Mich. Agr. Exp. Sta. Cir. Bull.* No. 231 (1961); R. S. Dyal, *National Symposium on Poultry Industry Waste Management* (Nebraska Center for Continuing Education, Lincoln, 1963); R. C. Loehr and M. Asce, *J. San. Eng. Division* 2 (1969), p. 189; L. W. McEachron, P. J. Zwerman, C. D. Kearl, R. B. Musgrave, *Animal Waste Management* (College of Agriculture, Cornell University, Ithaca, N.Y., 1969), pp. 393-400; T. C.

34. ...rook, C. C. Sheppard, J. S. Boyd, H. C. ...adel, C. J. Flegal, *Proc. Int. Symp. Livestock Wastes* (American Society of Agricultural Engineers, St. Joseph, Mo., 1971), p. 193.
35. N. B. Andrews, *The Response of Crops and Soils to Fertilizers and Manures* (Mississippi State University, State College, ed. 2, 1954); R. L. Cook, *Soil Management for Conservation and Production* (Wiley, New York, 1962), pp. 46–61; S. L. Tisdale and W. L. Nelson, *Soil Fertility and Fertilizers* (Macmillan, New York, 1966).
36. R. B. Linton, *Cornell Ext. Bull.* No. 1195 (1968).
37. J. R. Miner, *Iowa Agr. Exp. Sta. Spec. Rep.* No. 67 (1971).
38. U.S. Department of Agriculture, *Crop Production* (Crop Report Board, Washington, D.C., 1970).
39. President's Science Advisory Committee, *Report of the Environmental Pollution Panel* (White House, Washington, D.C., 1965), p. 172.
40. C. J. Willard *Ohio Agr. Exp. Sta. Bull.* No. 405 (1927).
41. H. D. Tate and O. S. Bare, *Nebr. Agr. Exp. Sta. Bull.* No. 381 (1946); pp. 1–12; R. E. Hill, E. Hixon, M. H. Muma, *J. Econ. Entomol.* 41, 392 (1948); C. L. Metcalf, W. P. Flint, R. L. Metcalf, *Destructive and Useful Insects* (McGraw-Hill, New York, 1962), p. 510; E. E. Ortman and P. J. Fitzgerald, *Proc. Ann. Hybrid Corn Ind. Res. Conf.* 19, 38 (1964); R. E. Robinson, *Agron. J.* 58, 475 (1966).
42. L. C. Pearson, *Principles of Agronomy* (Reinhold, New York, 1967), pp. 73–84.
43. National Academy of Sciences, *Principles of Plant and Animal Pest Control* II, Publication 1597 (National Academy of Sciences, Washington, D.C., 1968), pp. 256–257.
44. H. B. Sprague, *N.J. Agr. Exp. Sta. Bull.* 609, 1 (1936).
45. R. D. Munson and J. P. Doll, *Advan. Agr.* 11, 133 (1959).
46. J. S. Drew and R. N. Van Arsdall, *Ill. Agr. Econ.* 6, 25 (1966); D. L. Armstrong, J. K. Leasure, M. R. Corbin, *Weed Sci.* 16, 369 (1968); F. W. Slife, personal communication.
47. R. J. Delroit and H. L. Ahlgren, *Crop Production* (Prentice-Hall, Englewood Cliffs, N.J., 1953), pp. 572–573; P. W. Michael, *Herbage Abst.* 39, 59 (1969).
48. G. F. Sprague, *Corn and Corn Improvement* (Academic Press, New York, 1955), pp. 643 and 663.
49. National Academy of Sciences, *National Research Council Publication* No. 1232 (National Academy of Sciences, Washington, D.C., 1964), pp. 77–89; *ibid.*, No. 1684 (1969), pp. 38–45.
50. ... Harpstead, *Sci. Amer.* 225, 34 (1971).
51. U.S. Department of Agriculture, *Agr. Econ. Rep.* No. 147 (1968).
52. H. Jiler, *Commodity Yearbook* (Commodity Research Bureau, Inc., New York, 1972), pp. 252–253.
53. National Academy of Sciences, *Resources and Man* (Freeman, San Francisco, 1969), p. 143.
54. G. Borgström, *Principles of Food Science* (Macmillan, New York, 1968), vol. 2, p. 376.
55. U.S. Department of Agriculture, *Agricultural Statistics 1970* (Government Printing Office, Washington, D.C., 1970), pp. 28 and 430.
56. ———, *Fats and Oils Situation* (Economics Research Service, FOS-257, Washington, D.C., 1971).
57. G. R. Conway, *Environment, Resources, Pollution, and Society* (Sineurer Associates, Inc., Stamford, 1971), pp. 302–325; S. Pradhan, *World Sci. News* 8, 41 (1971).
58. J. N. Black, *Ann. Appl. Biol.* 67, 272 (1971).
59. U.S. Department of Agriculture, *Agricultural Statistics 1967* (Government Printing Office, Washington, D.C., 1967), pp. 34–35.
60. ———, *Crop Production, 1971 Annual Summary* (State Report Service, 1972).
61. ———, *Agr. Res. Ser. Stat. Bull.* No. 216 (1957).
62. ———, *Stat. Rep. Serv. Bull.* No. 408 (1967).
63. R. S. Berry and M. F. Fels, *The Production and Consumption of Automobiles. An Energy Analysis of the Manufacture, Discard, and Reuse of the Automobile and its Component Materials* (Univ. of Chicago, Chicago, 1973).
64. U.S. Department of Agriculture, *Bur. Agron. Econ. Bull.* No. FM 101 (1953).
65. U.S. Bureau of the Census, *Statistical Abstract of the U.S., 93rd Edition*, (Government Printing Office, Washington, D.C., 1972), pp. 600–601.
66. H. F. DeGraff and W. E. Washbon, *Agr. Econ.* No. 449 (1943).
67. U.S. Bureau of the Census, *Census of Agriculture 1964 II* (1968), pp. 909–955.
68. E. O. Heady, H. C. Madsen, K. J. Nicol, S. H. Hargrove, *Report of the Center for Agriculture and Rural Development*, prepared at Iowa State University, for the National Water Commission (NTIS, Springfield, Va., 1972).
69. A. W. Epp, *Nebr. Exp. Sta. Bull.* No. 426 (1954).
70. T. S. Thorfinnson, M. Hunt, A. W. Epp, *Nebr. Exp. Sta. Bull.* No. 432 (1955).
71. *Corn Grower's Guide* (W. R. Grace and Co., Aurora, Ill., 1968), p. 113.
72. U.S. ...eau of the Census, *Statistical Abstract for the United States, 92nd Edition* (Government Printing Office, Washington, D.C., 1971), p. 496.
73. ———, *Statistical Abstract of the United States, 86th Edition* (Government Printing Office, Washington, D.C., 1965), p. 538.
74. U.S. Department of Commerce, *Census of Transportation*, III (3), (Government Printing Office, Washington, D.C., 1967), pp. 102–105.
75. Interstate Commerce Commission, *Freight Commodity Statistics, Class I Motor Carriers of Property in Intercity* (Government Printing Office, Washington, D.C., 1968), p. 97; ———, *Freight and Commodity Statistics Class I Railroads* (Government Printing Office, Washington, D.C., 1968); ———, *Transportation Statistics* I, V, VII (Government Printing Office, Washington, D.C., 1968).
76. U.S. Department of Transportation, *Highway Statistics* (Government Printing Office, Washington, D.C., 1970), p. 5.
77. *Handbook of Chemistry and Physics* (Chemical Rubber Company, Cleveland, 1972), Table D-230.
78. A. J. Payne and J. A. Canner, *Chem. Process Eng.* 50, 81 (1969).
79. G. Leach and M. Slesser, *Energy Equivalents of Network Inputs to Food Producing Processes* (Univ. of Strathclyde, Glasgow, 1973).

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Energy Use in the U.S. Food System

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In a modern industrial society, only a tiny fraction of the population is in frequent contact with the soil, and an even smaller fraction of the population raises food on the soil. The proportion of the population engaged in farming halved between 1920 and 1950 and then halved again by 1962. Now it has almost halved again, and more than half of these remaining farmers hold other jobs off the farm (*1*). At the same time the number of work animals has declined from a peak of more than 22×10^6 in 1920 to a very small number at present (*2*). By comparison with earlier times, fewer farmers are producing more agricultural products and the value of food in terms of the total goods and services of society now amounts to a smaller fraction of the economy than it once did.

Energy inputs to farming have increased enormously during the past 50 years (*3*), and the apparent decrease in farm labor is offset in part by the growth of support industries for the farmer. With these changes on the farm have come a variety of other changes in the U.S. food system, many of which are now deeply embedded in the fabric of daily life. In the past 50 years, canned, frozen, and other processed foods have become the principal items of our diet. At present, the food processing industry is the fourth largest energy consumer of the Standard Industrial Classification groupings (*4*). The extent of transportation engaged in the food system has grown apace, and the proliferation of appliances in both numbers and complexity still continues in homes, institutions, and stores. Hardly any food is eaten as it comes from the fields. Even farmers purchase most of their food from markets in town.

Present energy supply problems make the growth of energy use in the food system worth investigating. It is our purpose in this article to do so. But there are larger matters at stake. Georgescu-Roegen notes that "the evidence now before us—of a world which can produce automobiles, television sets, etc., at a greater speed than the increase in population, but is simultaneously menaced by mass starvation—is disturbing" (*5*). In the search for a solution to the world's food problems, the common attempt to transplant a small piece of a highly industrialized food system to the hungry nations of the world is plausible enough, but so far the outcome is unclear. Perhaps an examination of the energy flow in the U.S. food system as it has developed can provide some insights that are not available from the usual economic measures.

Measures of Food Systems

Agricultural systems are most often described in economic terms. A wealth of statistics is collected in the United States and in most other technically advanced countries indicating production amounts, shipments, income, labor, expenses, and dollar flow in the agricultural sector of the economy. But, when we wish to know something about the food we actually eat, the statistics of farms are only a tiny fraction of the story.

Energy flow is another measure available to gauge societies and nations. It would have made no sense to measure societies in terms of energy flow in the 18th century when economics began. As recently as 1940, four-fifths of the world's population were still on farms and in small villages, most of them engaged in subsistence farming.

Only after some nations shifted large portions of the population to manufacturing, specialized tasks, and mechanized food production, and shifted the prime sources of energy to move society to fuels that were transportable and usable for a wide variety of alternative activities, could energy flow be used as a measure of societies' activities. Today it is only in one-fifth of the world where these conditions are far advanced. Yet we can now make comparisons of energy flows even with primitive societies. For even if the primitives, or the euphemistically named "underdeveloped" countries, cannot shift freely among their energy expenditures, we *can* measure them and they constitute a different and potentially useful comparison with the now traditional economic measures.

What we would like to know is: How does our present food supply system compare, in energy measures, with those of other societies and with our own past? Perhaps then we can estimate the value of energy flow measures as an adjunct to, but different from, economic measures.

Energy in the U.S. Food System

A typical breakfast includes orange juice from Florida by way of the Minute Maid factory, bacon from a midwestern meat packer, cereal from Nebraska and General Mills, eggs and milk from not *too* far away, and coffee from Colombia. All of these things are available at the local supermarket (several miles each way in a 300-horsepower automobile), stored in a refrigerator-freezer, and cooked on an instant-on stove.

The present food system in the United States is complex, and the attempt to analyze it in terms of energy use will introduce complexities and questions far more perplexing than the same analysis carried out on simpler societies. Such an analysis is worthwhile, however, if only to find out where we stand. We have a food system, and most people get enough to eat from it. If, in addition, one considers the food supply problems present and future in societies where a smaller fraction of the people get enough to eat, then our experience with an industrialized food system is even more important. There is simply no gainsaying that many nations of the world are presently attempting to acquire industrialized food systems of their own.

Food in the United States is expensive by world standards. In 1970 the average annual per capita expenditure for food was about $600 (*3*). This amount is larger than the per capita gross domestic product of more than 30 nations of the world which contain the majority of the world's people and a vast majority of those who are under-

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• Courtesy U.S. Department of Agriculture, Washington, D.C

fed. Even if we consider the diet of a poor resident of India, the annual cost of his food at U.S. prices would be about $200—more than twice his annual income (*3*). It is crucial to know whether a piece of our industrialized food system can be exported to help poor nations, or whether they must become as industrialized as the United States to operate an industrialized food system.

Our analysis of energy use in the food system begins with an omission. We will neglect that crucial input of energy provided by the sun to the plants upon which the entire food supply depends. Photosynthesis has an efficiency of about 1 percent; thus the maximum solar radiation captured by plants is about 5×10^{3} kilocalories per square meter per year (*3*).

Seven categories of energy use on the farm are considered here. The amounts of energy used are shown in Table 1. The values given for farm machinery and tractors are for the manufacture of new units only and do not include parts and maintenance for units that already exist. The amounts shown for direct fuel use and electricity consumption are a bit too high because they include some residential uses of the farmer and his family. On the other hand, some uses in these categories are not reported in the summaries used to obtain the values for direct fuel and electricity usage. These and similar problems are discussed in the references. N[illegible]relatively high energy cost associated with irrigation. In the United States less than 5 percent of the cropland is irrigated (*1*). In some countries where the "green revolution" is being attempted, the new high-yield varieties of plants require irrigation where native crops did not. If that were the case in the United States, irrigation would be the largest single use of energy on the farm.

Little food makes its way directly from field and farm to the table. The vast complex of processing, packaging, and transport has been grouped together in a second major subdivision of the food system. The seven categories of the processing industry are listed in Table 1. Energy use for the transport of food should be charged to the farm in part, but we have not done so here because the calculation of the energy values is easiest (and we believe most accurate) if they are taken for the whole system.

After the processing of food there is further energy expenditure. Transportation enters the picture again, and some fraction of the energy used for transportation should be assigned here. But there are also the distributors, wholesalers, and retailers, whose freezers, refrigerators, and very establishments are an integral part of the food system. There are also the restaurants, schools, universities, prisons, and a host of other institutions engaged in the procurement, preparation, storage, and supply of food. We have chosen to examine only three categories: the energy required for refrigeration and cooking, and for the manufacture of the heating and refrigeration equipment (Table 1). We have made no attempt to include the energy used in trips to the store or restaurant. Garbage disposal has also been omitted, although it is a persistent and growing feature of our food system; 12 percent of the nation's trucks are engaged in the activity of waste disposal (*1*), of which a substantial part is related to food. If there is any lingering doubt that these activities—both the ones included and the ones left out—are an essential feature of our present food system, one need only ask what would happen if everyone should attempt to get on without a refrigerator or freezer or stove? Certainly the food system would change.

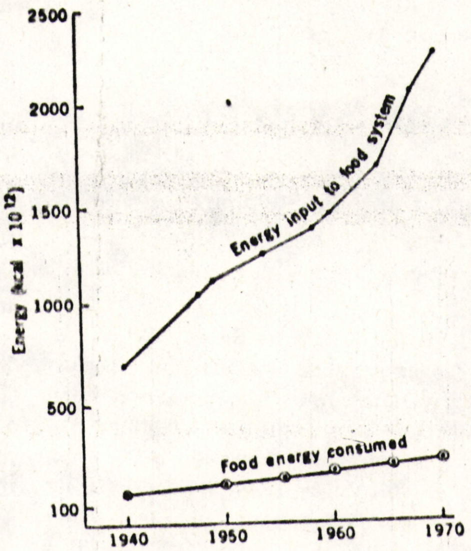


Fig. 1. Energy use in the food system, 1940 through 1970, compared to the caloric content of food consumed.

Table 1 and the related references summarize the numerical values for energy use in the U.S. food system, from 1940 to 1970. As for many activities in the past few decades, the story is one of continuing increase. The totals are displayed in Fig. 1 along with the energy value of the food consumed by the public. The food values were obtained by multiplying the daily caloric intake by the population. The differences in caloric intake per capita over this 30-year period are small (*1*), and the curve is primarily an indication of the increase in population in this period.

Omissions and Duplications for Food System Energy Values

Several omissions, duplications, and overlaps have been mentioned. We will now examine the values in Table 1 for completeness and try to obtain a crude estimate of their numerical accuracy.

The direct fuel and electricity usage on the farm may be overstated by some amounts used in the farmer's household, which, by our approach, would not all be chargeable to the food system. But about 10 percent of the total acreage farmed is held by corporate farms for which the electrical and direct fuel use is not included in our data. Other estimates of these two categories are much higher [see Table 1 (*15, 16*)].

No allowance has been made for food exported, which has the effect of overstating the energy used in our own food system. For the years prior to 1960 the United States was at times a net importer of food, at times an exporter, and at times there was a near balance in this activity. But during this period the net flow of trade was never more than a few percent of the total farm output. Since 1960 net exports have increased to about 20 percent of the gross farm product (*1, 3*). The items comprising the vast majority of the exports have been rough grains, flour, and other plant products with very little processing. Imports include more processed food than exports and represent energy expenditure outside the United States. Thus the overestimate of energy input to the food system might be 5 percent with an upper limit of 15 percent.

The items omitted are more numerous. Fuel losses from the wellhead or mineshaft to end use total 10 to 12 percent (*6*). This would represent a flat addition of 10 percent or more to the totals, but we have not included this item because it is not customarily charged to end uses.

We have computed transport energy

for trucks only. Considerable food is transported by train and ship, but these items were omitted because the energy use is small relative to the consumption of truck fuel. Small amounts of food are shipped by air, and, although air shipment is energy intensive, the amount of energy consumed appears small. We have traced support materials until they could no longer be assigned to the food system. Some transportation energy consumption is not charged in the transport of these support materials. These omissions are numerous and hard to estimate, but they would not be likely to increase the totals by more than 1 or 2 percent.

A more serious understatement of energy usage occurs with respect to vehicle usage (other than freight transport) on farm business, food-related business in industry and commercial establishments, and in the supporting industries. A special attempt to estimate this category of energy usage for 1968 suggests that it amounts to about 5 percent of the energy totals for the food system. This estimate would be subject to an uncertainty of nearly 100 percent. We must be satisfied to suggest that 1 to 10 percent should be added to the totals on this account.

Waste disposal is related to the food system, at least in part. We have chosen not to charge this energy to the food system, but, if one-half of the waste disposal activity is taken as food-related, about 2 percent must be added to the food system energy totals.

We have not included energy for parts and maintenance of machinery, vehicles, buildings, and the like, or lumber for farm, industry, or packaging uses. These miscellaneous activities would not constitute a large addition in any case. We have also excluded construction. Building and replacement of farm structures, food industry structures, and commercial establishments are all directly part of the food system. Construction of roads is in some measure related to the food system, since nearly half of all trucks transport food and agricultural items [see Table 1 (*27*)]. Even home construction could be charged in part to the food system since space, appliances, and plumbing are, in part, a consequence of the food system. If 10 percent of housing, 10 percent of institutional construction (for institutions with food service), and 10 percent of highway construction is included, about 10 percent of the total construction was food-related in 1970. Assuming that the total energy consumption divides in the same way that the Gross National Product does (which overstates energy use in construction), the addition to the total in Table 1 would be about 10 percent or 200×10^{12} kcal. This is a crude and highly simplified calculation, but it does provide an estimate of the amounts of energy involved.

The energy used to generate the highly specialized seed and animal stock has been excluded because there is no easy way to estimate it. Pimentel *et al.* (*3*) estimate that 1800 kcal are required to produce 1 pound (450 grams) of hybrid corn seed. But in addition to this amount, some energy use should be included for all the schools of agriculture, agricultural experiment stations, the far-flung network of county agricultural agents [one local agent said he traveled over 50,000 automobile miles (80,000 kilometers) per year in his car], the U.S. Department of Agriculture, and the wide-ranging agricultural research program that enables man to stay ahead of the new pest and disease threats to our highly specialized food crops. These are extensive activities but we cannot see how they could add more than a few percent to the totals in Table 1.

Finally, we have made no attempt to include the amount of private automobile usage involved in the delivery system from retailer to home, or other food-related uses of private autos. Rice (*7*) reports 4.25×10^{15} kcal for the energy cost of autos in 1970, and shopping constitutes 15.2 percent of all automobile usage (*8*). If only half of the shopping is food-related, 320×10^{12} kcal of energy use is at stake here.

Table 1. Energy use in the United States food system. All values are multiplied by 10^{12} kcal.

Component	1940	1947	1950	1954	1958	1960	1964	1968	1970	References
On farm										
Fuel (direct use)	70.0	136.0	158.0	172.8	179.0	188.0	213.9	226.0	232.0	(*13-15*)
Electricity	0.7	32.0	32.9	40.0	44.0	46.1	50.0	57.3	63.8	(*14, 16*)
Fertilizer	12.4	19.5	24.0	30.6	32.2	41.0	60.0	87.0	94.0	(*14, 17*)
Agricultural steel	1.6	2.0	2.7	2.5	2.0	1.7	2.5	2.4	2.0	(*14, 18*)
Farm machinery	9.0	34.7	30.0	29.5	50.2	52.0	60.0	75.0	80.0	(*14, 19*)
Tractors	12.8	25.0	30.8	23.6	16.4	11.8	20.0	20.5	19.3	(*20*)
Irrigation	18.0	22.8	25.0	29.6	32.5	33.3	34.1	34.8	35.0	(*21*)
Subtotal	124.5	272.0	303.4	328.6	356.3	373.9	440.5	503.0	526.1	
Processing industry										
Food processing industry	147.0	177.5	192.0	211.5	212.6	224.0	249.0	295.0	308.0	(*13, 14, 22*)
Food processing machinery	0.7	5.7	5.0	4.9	4.9	5.0	6.0	6.0	6.0	(*23*)
Paper packaging	8.5	14.8	17.0	20.0	26.0	28.0	31.0	35.7	38.0	(*24*)
Glass containers	14.0	25.7	26.0	27.0	30.2	31.0	34.0	41.9	47.0	(*25*)
Steel cans and aluminum	38.0	55.8	62.0	73.7	85.4	86.0	91.0	112.2	122.0	(*26*)
Transport (fuel)	49.6	86.1	102.0	122.3	140.2	153.3	184.0	226.6	246.9	(*27*)
Trucks and trailors (manufacture)	28.0	42.0	49.5	47.0	43.0	44.2	61.0	70.2	74.0	(*28*)
Subtotal	285.8	407.6	453.5	506.4	542.3	571.5	656.0	787.6	841.9	
Commercial and home										
Commercial refrigeration and cooking	121.0	141.0	150.0	161.0	176.0	186.2	209.0	241.0	263.0	(*13, 29*)
Refrigeration machinery (home and commercial)	10.0	24.0	25.0	27.5	29.4	32.0	40.0	56.0	61.0	(*14, 30*)
Home refrigeration and cooking	144.2	184.0	202.3	228.0	257.0	276.6	345.0	433.9	480.0	(*13, 29*)
Subtotal	275.2	349.0	377.3	416.5	462.4	494.8	594.0	730.9	804.0	
Grand total	685.5	1028.6	1134.2	1251.5	1361.0	1440.2	1690.5	2021.5	2172.0	

Between 8 and 15 percent should be added to the totals of Table 1, depending on just how one wishes to apportion this item.

It is hard to take an approach that might calculate smaller totals but, depending upon point of view, the totals could be much larger. If we accumulate the larger estimates from the above paragraphs as well as the reductions, the total could be enlarged by 30 to 35 percent, especially for recent years. As it is, the values for energy use in the food system from Table 1 account for 12.8 percent of the total U.S. energy use in 1970.

Performance of an Industrialized Food System

The difficulty with history as a guide for the future or even the present lies not so much in the fact that conditions change—we are continually reminded of that fact—but that history is only one experiment of the many that might have occurred. The U.S. food system developed as it did for a variety of reasons, many of them not understood. We would do well to examine some of the dimensions of this development before attempting to theorize about how it might have been different, or how parts of this food system can be transplanted elsewhere.

Energy and Food Production

Figure 2 displays features of our food system not easily seen from economic data. The curve shown has no theoretical basis but is suggested by the data as a smoothed recounting of our own history of increasing food production. It is, however, similar to most growth curves and suggests that, to the extent that the increasing energy subsidies to the food system have increased food production, we are near the end of an era. Like the logistic growth curve, there is an exponential phase which lasted from 1920 or earlier until 1950 or 1955. Since then, the increments in production have been smaller despite the continuing growth in energy use. It is likely that further increases in food production from increasing energy inputs will be harder and harder to come by. Of course, a major change in the food system could change things, but the argument advanced by the technological optimist is that we can always get more if we

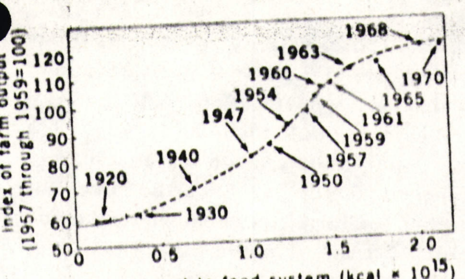


Fig. 2. Farm output as a function of energy input to the U.S. food system, 1920 through 1970.

have enough energy, and that no other major changes are required. Our own history—the only one we have to examine—does not support that view.

Energy and Labor in the Food System

One farmer now feeds 50 people, and the common expectation is that the labor input to farming will continue to decrease in the future. Behind this expectation is the assumption that the continued application of technology—and energy—to farming will substitute for labor. Figure 3 shows this historic decline in labor as a function of the energy supplied to the food system, again the familiar S-shaped curve. What it implies is that increasing the energy input to the food system is unlikely to bring further reduction in farm labor unless some other, major change is made.

The food system that has grown in this period has provided much employment that did not exist 20, 30, or 40 years ago. Perhaps even the idea of a reduction of labor input is a myth when the food system is viewed as a whole, instead of from the point of view of the farm worker only. When discussing

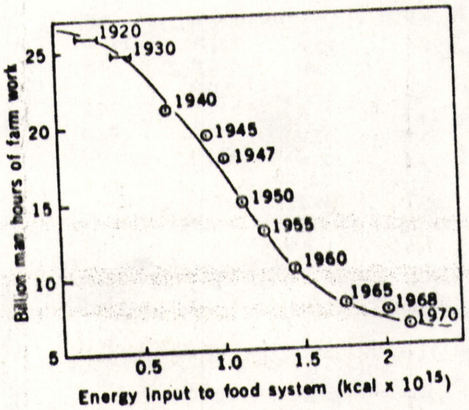


Fig. 3. Labor use on farms as a function of energy use in the food system.

inputs to the farm, Pimentel *et al.* (3) cite an estimate of two farm support workers for each person actually on the farm. To this must be added employment in food-processing industries, in food wholesaling and retailing, as well as in a variety of manufacturing enterprises that support the food system. Yesterday's farmer is today's canner, tractor mechanic, and fast food carhop. The process of change has been painful to many ordinary people. The rural poor, who could not quite compete in the growing industrialization of farming, migrated to the cities. Eventually they found other employment, but one must ask if the change was worthwhile. The answer to that question cannot be provided by energy analysis anymore than by economic data, because it raises fundamental questions about how individuals would prefer to spend their lives. But if there is a stark choice between long hours as a farmer or shorter hours on the assembly line of a meat-packing plant, it seems clear that the choice would not be universally in favor of the meat-packing plant. Thomas Jefferson dreamed of a nation of independent small farmers. It was a good dream, but society did not develop in that way. Nor can we turn back the clock to recover his dream. But, in planning and preparing for our future, we had better look honestly at our collective history, and then each of us should closely examine his dreams.

The Energy Subsidy to the Food System

The data in Fig. 1 can be combined to show the energy subsidy provided to the food system for the recent past. We take as a measure of the food supplied the caloric content of the food actually consumed. This is not the only measure of the food supplied, as the condition of many protein-poor peoples of the world clearly shows. Nevertheless, the comparison between caloric input and output is a convenient way to compare our present situation with the past, and to compare our food system with others. Figure 4 shows the history of the U.S. food system in terms of the number of calories of energy supplied to produce 1 calorie of food for actual consumption. It is interesting and possibly threatening to note that there is no real suggestion that this curve is leveling off. We appear to be increasing the energy input even more. Fragmentary data for 1972 suggest that the increase continued unabated. A graph

...4 could approach zero. A natural system has no fuel input at all, and those primitive people who live by hunting and gathering have only the energy of their own work to count as input.

Some Economic Features of the U.S. Food System

The markets for farm commodities in the United States come closer than most to the economist's ideal of a "free market." There are many small sellers and many buyers, and thus no individual is able to affect the price by his own actions in the marketplace. But government intervention can drastically alter any free market, and government intervention in the prices of agricultural products (and hence of food) has been a prominent feature of the U.S. food system for at least 30 years. Between 1940 and 1970, total farm income has ranged from $4.5 to $16.5 billion, and the National Income originating in agriculture (which includes indirect income from agriculture) has ranged from $14.5 to $22.5 billion (*1*). Meanwhile, government subsidy programs, primarily farm price supports and soil bank payments, have grown from $1.5 billion in 1940 to $6.2 billion in 1970. In 1972 these subsidy programs had grown to $7.3 billion, despite foreign demand of agricultural products. Viewed in a slightly different way, direct government subsidies have accounted for 30 to 40 percent of the farm income and 15 to 30 percent of the National Income attributable to agriculture for the years since 1955. This point emphasizes once again the striking gap between the economic description of society and the economic models used to account for that society's behavior.

This excursion into farm price supports and economics is related to energy questions in this way: first, so far as we know, government intervention in the food system is a feature of all highly industrialized countries (and, despite the intervention, farm incomes still tend to lag behind national averages); and, second, reduction of the energy subsidy to agriculture (even if we could manage it) might decrease the farmer's income. One reason for this state of affairs is that the demand for food quantity has definite limits, and the only way to increase farm income is then to increase the unit price of agricultural products. Consumer boycotts and protests in the early 1970's suggest that there is considerable resistance to this outcome.

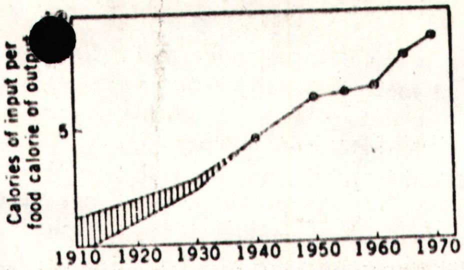


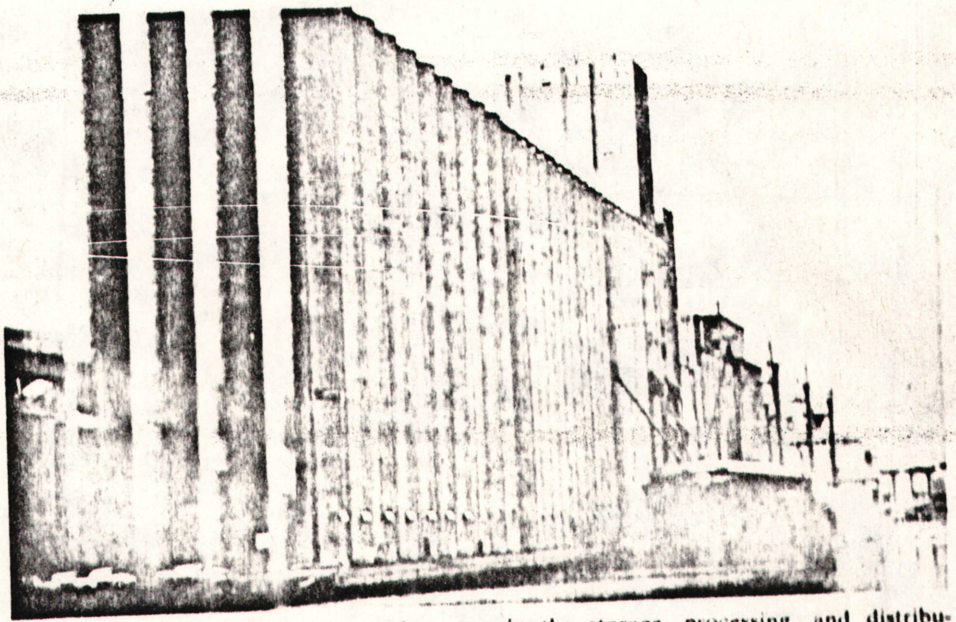
Fig. 4. Energy subsidy to the food system needed to obtain 1 food calorie.

Government intervention in the functioning of the market in agricultural products has accompanied the rise in the use of energy in agriculture and the food supply system, and we have nothing but theoretical suppositions to suggest that any of the present system can be deleted.

Some Energy Implications for the World Food Supply

The food supply system of the United States is complex and interwoven into a highly industrialized economy. We have tried to analyze this system on account of its implications for future energy use. But the world is short of food. A few years ago it was widely predicted that the world would suffer widespread famine in the 1970's. The adoption of new high-yield varieties of rice, wheat, and other grains has caused some experts to predict that the threat of the expected famines can now be averted, perhaps indefinitely. Yet, despite increases in grain production in some areas, the world still seems to be headed toward famine. The adoption of these new varieties of grain—dubbed hopefully the "green revolution"—is an attempt to export a part of the energy-intensive food system of the highly industrialized countries to nonindustrialized countries. It is an experiment, because, although the whole food system is not being transplanted to new areas, a small part of it is. The green revolution requires a great deal of energy. Many of the new varieties of grain require irrigation where traditional crops did not, and almost all the new crops require extensive fertilization.

Meanwhile, the agricultural surpluses of the 1950's have largely disappeared. Grain shortages in China and Russia have attracted attention because they have brought foreign trade across ideological barriers. There are other countries that would probably import considerable grain, if they could afford it. But only four countries may be expected to have any substantial excess agricultural production in the next decade. These are Canada, New Zealand, Australia, and the United States. None of these is in a position to give grain away, because each of them needs the foreign trade to avert ruinous balance of payments deficits. Can we then export energy-intensive agricultural methods instead?


Giant grain elevators are only a first step in the storage, processing, and distribution portions of the food system. [Source: Marine Studies Center, University of Wisconsin]

Energy-Intensive Agriculture Abroad

It is quite clear that the U.S. food system cannot be exported intact at present. For example, India has a population of 550×10^6 persons. To feed the people of India at the U.S. level of about 3000 food calories per day (instead of their present 2000) would require more energy than India now uses for all purposes. To feed the entire world with a U.S. type food system, almost 80 percent of the world's annual energy expenditure would be required just for the food system.

The recourse most often suggested to remedy this difficulty is to export methods of increasing crop yield and hope for the best. We must repeat as plainly as possible that this is an experiment. We know that our food system works (albeit with some difficulties and warnings for the future). But we cannot know what will happen if we take a piece of that system and transplant it to a poor country, without our industrial base of supply, transport system, processing industry, appliances for home storage, and preparation, and, most important of all, a level of industrialization that permits higher costs for food.

Fertilizers, herbicides, pesticides, and in many cases machinery and irrigation are needed for success with the green revolution. Where is this energy to come from? Many of the nations with the most serious food problems are those nations with scant supplies of fossil fuels. In the industrialized nations, solutions to the energy supply problems are being sought in nuclear energy. This technology-intensive solution, even if successful in advanced countries, poses additional problems for underdeveloped nations. To create the bases of industry and technologically sophisticated people within their own countries will be beyond the capability of many of them. Here again, these countries face the prospect of depending upon the goodwill and policies of industrialized nations. Since the alternative could be famine, their choices are not pleasant and their irritation at their benefactors—ourselves among them—could grow to threatening proportions. It would be comfortable to rely on our own good intentions, but our good intentions have often been unresponsive to the needs of others. The matter cannot be glossed over lightly. World peace may depend upon the outcome.

Changes for the Future

The total amount of energy used on U.S. farms for the production of corn is now near 10^3 kcal per square meter per year (*3*), and this is more or less typical of intensive agriculture in the United States. With this application of energy we have achieved yields of 2×10^3 kcal per square meter per year of usable grain—bringing us to almost half of the photosynthetic limit of production. Further applications of energy are likely to yield little or no increase in this level of productivity. In any case, no amount of research is likely to improve the efficiency of the photosynthetic process itself. There is a further limitation on the improvement of yield. Faith in technology and research has at times blinded us to the basic limitations of the plant and animal material with which we work. We have been able to emphasize desirable features already present in the gene pool and to suppress others that we [illegible] desirable. At times the cost of the increased yield has been the loss of desirable characteristics—hardiness, resistance to disease and adverse weather, and the like. The farther we get from characteristics of the original plant and animal strains, the more care and energy is required. Choices need to be made in the directions of plant breeding. And the limits of the plants and animals we use must be kept in mind. We have not been able to alter the photosynthetic process or to change the gestation period of animals. In order to amplify or change an existing characteristic, we will probably have to sacrifice something in the overall performance of the plant or animal. If the change requires more energy, we could end with a solution that is too expensive for the people who need it most. These problems are intensified by the degree to which energy becomes more expensive in the world market.

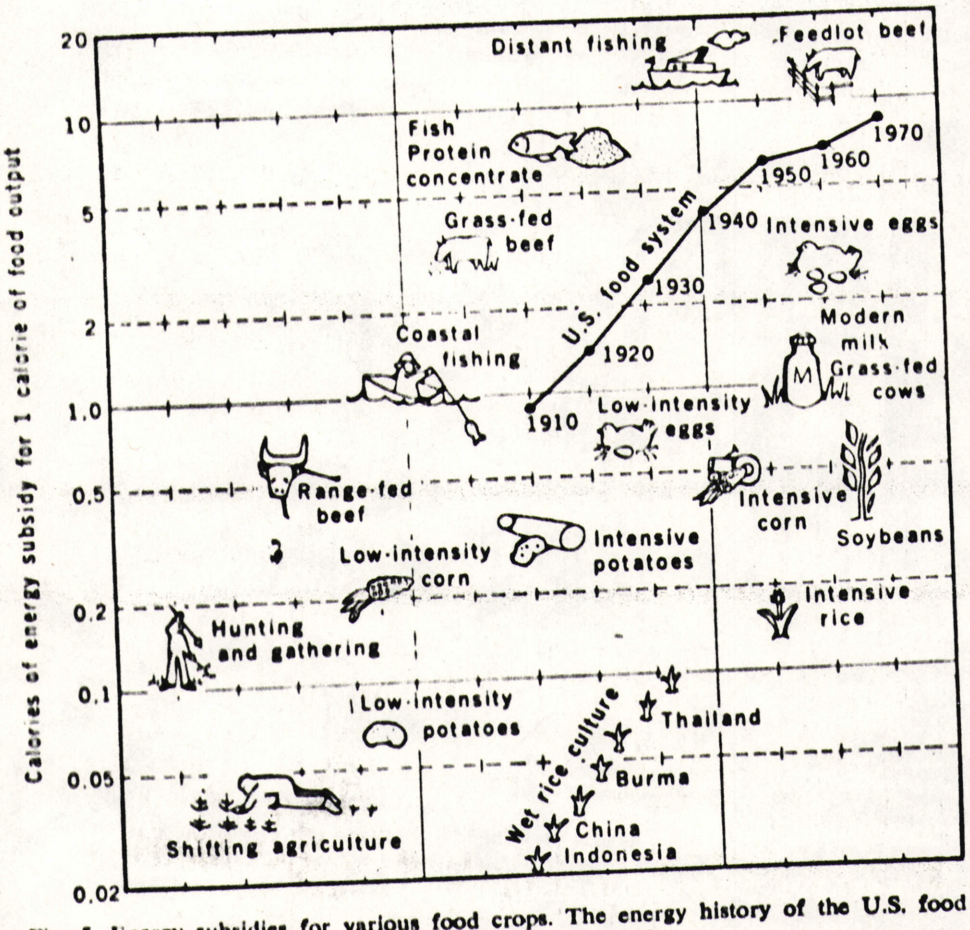


Fig. 5. Energy subsidies for various food crops. The energy history of the U.S. food system is shown for comparison. [Source of data: (*31*)]

Where Next to Look for Food?

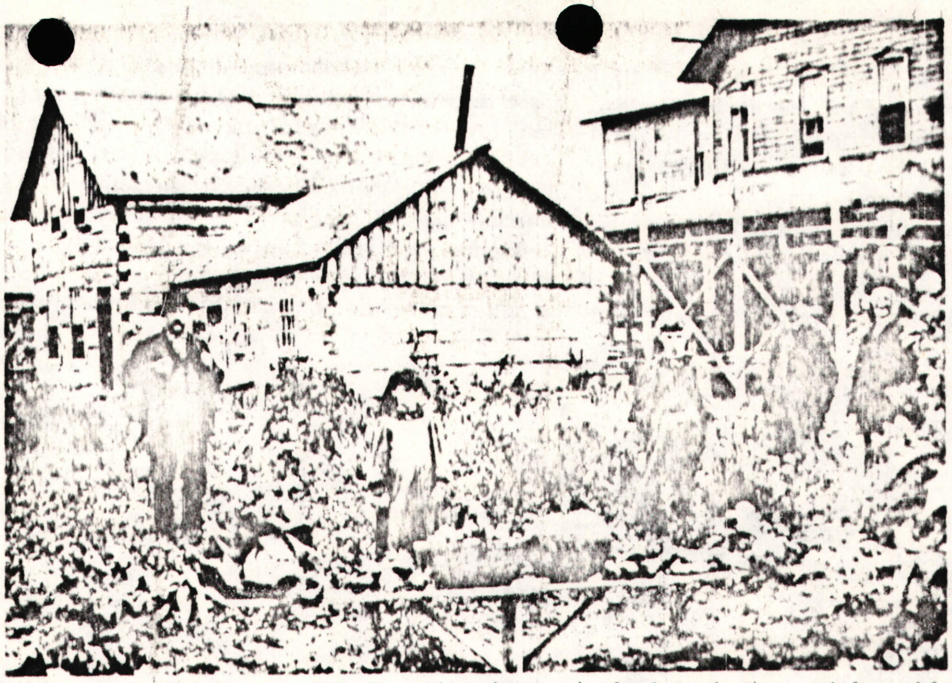
Our examination in the foregoing pages of the U.S. food system, the limitations on the manipulation of ecosystems and their components, and the risks of the green revolution as a solution to the world food supply problem suggests a bleak prospect for the future. This complex of problems should not be underestimated, but there are possible ways of avoiding disaster and of mitigating the severest difficulties

...ggestions are not very dramat-...s may be difficult of common ...ptance.

...igure 5 shows the ratio of the ...ergy subsidy to the energy output for a number of widely used foods in a variety of times and cultures. For comparison, the overall pattern for the U.S. food system is shown, but the comparison is only approximate because, for most of the specific crops, the energy input ends at the farm. As has been pointed out, it is a long way from the farm to the table in industrialized societies. Several things are immediately apparent and coincide with expectations. High-protein foods such as milk, eggs, and especially meat, have a far poorer energy return than plant foods. Because protein is essential for human diets and the amino acid balance necessary for good nutrition is not found in most of the cereal grains, we cannot take the step of abandoning meat sources altogether. Figure 5 does show how unlikely it is that increased fishing or fish protein concentrate will solve the world's food problems. Even if we leave aside the question of whether the fish are available—a point on which expert opinions differ somewhat—it would be hard to imagine, with rising energy prices, that fish protein concentrate will be anything more than a by-product of the fishing industry, because it requires more than twice the energy of production of grass-fed beef or eggs (9). Distant fishing is still less likely to solve food problems. On the other hand, coastal fishing is relatively low in energy cost. Unfortunately, without the benefit of scholarly analysis fisherman and housewives have long known this, and coastal fisheries are threatened with overfishing as well as pollution.

The position of soybeans in Fig. 5 may be crucial. Soybeans possess the best amino acid balance and protein content of any widely grown crop. This has long been known to the Japanese who have made soybeans a staple of their diet[illegible]here other plants, possibly better suited for local climates, that have adequate proportions of amino acids in their proteins? There are about 80,000 edible species of plants, of which only about 50 are actively cultivated on a large scale (and 90 percent of the world's crops come from only 12 species). We may yet be able to find species that can contribute to the world's food supply.

The message of Fig. 5 is simple. In "primitive" cultures, 5 to 50 food calories were obtained for each calorie of energy invested. Some highly civilized cultures have done as well and occasionally better. In sharp contrast, industrialized food systems require 5 to 10 calories of fuel to obtain 1 food calorie. We must pay attention to this difference—especially if energy costs increase. If some of the energy subsidy for food production could be supplied by on-site, renewable sources—primarily sun and wind—we might be able to continue an energy-intensive food system. Otherwise, the choices appear to be either less energy-intensive food production or famine for many areas of the world.



A Wisconsin farm about 1910. Extensive changes in food production and farm life are part of the food system. [Source: Wisconsin Historical Society]

Energy Reduction in Agriculture

It is possible to reduce the energy required for agriculture and the food system. A series of thoughtful proposals by Pimentel and his associates (*3*) deserves wide attention. Many of these proposals would help ameliorate environmental problems, and any reductions in energy use would provide a direct reduction in the pollutants due to fuel consumption as well as more time to solve our energy supply problems.

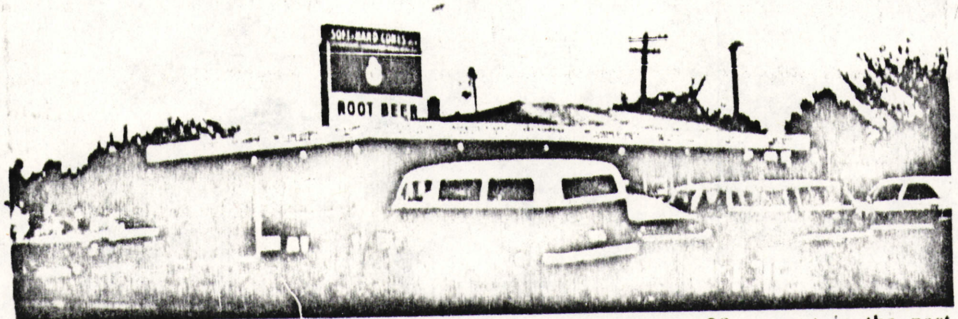
First, we should make more use of natural manures. The United States has a pollution problem from runoff from animal feedlots, even with the application of large amounts of manufactured fertilizer to fields. More than 10^6 kcal per acre (4×10^5 kcal per hectare) could be saved by substituting manure for manufactured fertilizer (*3*) (and, as a side benefit, the soil's condition would be improved). Extensive expansion in the use of natural manure will require decentralization of feedlot operations so that manure is generated closer to the point of application. Decentralization might increase feedlot costs, but, as energy prices rise, feedlot operations will rapidly become more expensive in any case. Although the use of manures can help reduce energy use, there is far too little to replace all commercial fertilizers at present (*10*). Crop rotation is less widely practiced than it was even 20 years ago. Increased use of crop rotation or interplanting winter cover crops of legumes (which fix nitrogen as a green manure) would [illegible] 1.5×10^6 kcal per acre by comparison with the use of commercial fertilizer.

Second, weed and pest control could be accomplished at a much smaller cost in energy. A 10 percent saving in energy in weed control could be obtained by the use of the rotary hoe twice in cultivation instead of herbicide application (again with pollution abatement as a side benefit). Biologic pest control —that is, the use of sterile males, introduced predators, and the like—requires only a tiny fraction of the energy of pesticide manufacture and application. A change to a policy of "treat when and where necessary" pesticide application would bring a 35 to 50 percent reduction in pesticide use. Hand application of pesticides requires more labor than machine or aircraft application, but the energy for application is reduced from 18,000 to 300 kcal per acre (*3*). Changed cosmetic standards, which in no way affect the taste or the edibility of foodstuffs, could also bring about a substantial reduction in pesticide use.

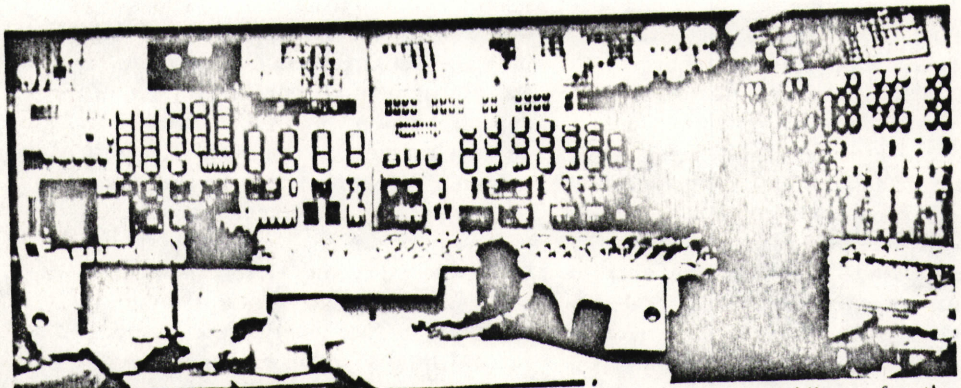
Third, plant breeders might pay more attention to hardiness, disease and pest resistance, reduced moisture content (to end the wasteful use of natural gas in drying crops), reduced water requirements, and increased protein content, even if it should mean some reduction in overall yield. In the longer run, plants not now widely cultivated might receive some serious attention and breeding efforts. It seems unlikely that the crops that have been most useful in temperate climates will be the most suitable ones for the tropics where a large portion of the undernourished peoples of the world now live.

A dramatic suggestion, to abandon chemical farming altogether, has been made by Chapman (*11*). His analysis shows that, were chemical farming to be ended, there would be much reduced yields per acre, so that most land in the soil bank would need to be put back into farming. Nevertheless, output would fall only 5 percent and prices for farm products would increase 16 percent. Most dramatically, farm income would rise 25 percent, and nearly all subsidy programs would end. A similar set of propositions treated with linear programming techniques at Iowa State University resulted in an essentially similar set of conclusions (*12*).

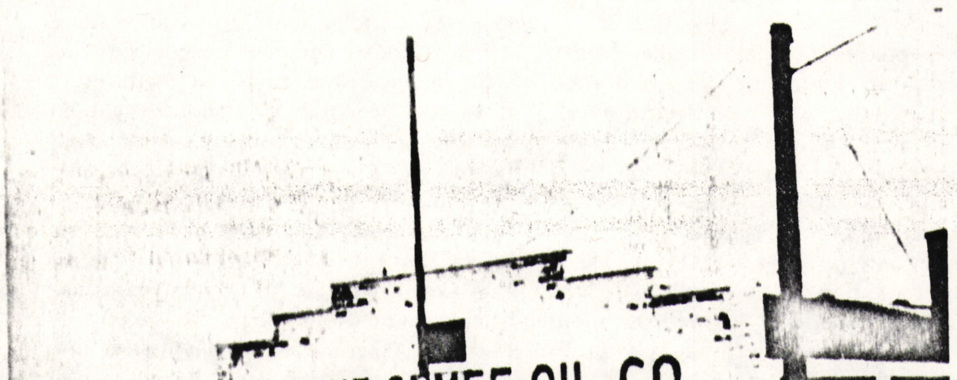
The direct use of solar energy farms, a return to wind power (modern windmills are now in use in Australia), and the production of methane from manure are all possibilities. These methods require some engineering to become economically attractive, but it should be emphasized that these technologies are now better understood than the technology of breeder reactors. If energy prices rise, these methods of energy generation would be attractive alternatives, even at their present costs of implementation.



Commercial and institution food service has grown by almost 20 percent in the past decade. [Source: Marine Studies Center, University of Wisconsin]



Use of electricity in the food system has been growing at least as rapidly as for the United States as a whole. This nuclear power plant control room is another part of the food system. [Source: Marine Studies Center, University of Wisconsin]



Behind the food system at every stage is the fuel production, refining, and distribution system. [Source: Marine Studies Center, University of Wisconsin]

Energy Reduction in the U.S. Food System

Beyond the farm, but still far from the table, more energy savings could be introduced. The most effective way to reduce the large energy requirements of food processing would be a change in eating habits toward less highly processed foods. The current aversion of young people to spongy, additive-laden white bread, hydrogenated peanut butter, and some other processed foods could presage such a change if it is more than just a fad. Technological changes could reduce energy consumption, but the adoption of lower energy methods would be hastened most by an increase in energy prices, which would make it more profitable to reduce fuel use.

Packaging has long since passed the stage of simply holding a convenient amount of food together and providing it with some minimal protection. Legislative controls may be needed to reduce the manufacturer's competition in the amount and expense of packaging. In any case, recycling of metal containers and wider use of returnable bottles could reduce this large item of energy use.

The trend toward the use of trucks in food transport, to the virtual exclusion of trains, should be reversed. By reducing the direct and indirect subsidies to trucks we might go a long way toward enabling trains to compete.

Finally, we may have to ask whether the ever-larger frostless refrigerators are needed, and whether the host of kitchen appliances really means less work or only the same amount of work to a different standard.

Store delivery routes, even by truck, would require only a fraction of the energy used by autos for food shopping. Rapid transit, giving some attention to the problems with shoppers with parcels, would be even more energy-efficient. If we insist on a high-energy food system, we should consider starting with coal, oil, garbage—or any other source of hydrocarbons—and producing in factories bacteria, fungi, and yeasts. These products could then be flavored and colored appropriately for cultural tastes. Such a system would be more efficient in the use of energy, would solve waste problems, and would permit much or all of the agricultural land to be returned to its natural state.

Energy, Prices, and Hunger

If energy prices rise, as they have already begun to do, the rise in the price of food in societies with industrialized agriculture can be expected to be even larger than the energy price increases. Slesser, in examining the case for England, suggests that a quadrupling of energy prices in the next 40 years would bring about a sixfold increase in food prices (9). Even small increases in energy costs may make it profitable to increase labor input to food production. Such a reversal of a 50-year trend toward energy-intensive agriculture would present environmental benefits as a bonus.

We have tried to show how analysis of the energy flow in the food system illustrates features of the food system that are not easily deduced from the usual economic analysis. Despite some suggestions for lower intensity food supply and some frankly speculative suggestions, it would be hard to conclude on a note of optimism. The world drawdown in grain stocks which began in the mid-1960's continues, and some food shortages are likely all through the 1970's and early 1980's. Even if population control measures begin to limit world population, the rising tide of hungry people will be with us for some time.

Food is basically a net product of an ecosystem, however simplified. Food production starts with a natural material, however modified later. Injections of energy (and even brains) will carry us only so far. If the population cannot adjust its wants to the world in which it lives, there is little hope of solving the food problem for mankind. In that case the food shortage will solve our population problem.

References and Notes

1. *Statistical Abstract of the United States* (Government Printing Office, Washington, D.C., various annual editions).
2. *Historical Statistics of the United States* (Government Printing Office, Washington, D.C., 1960).
3. D. Pimentel, L. E. Hurd, A. C. Bellotti, M. J. Forster, I. N. Oka, O. D. Scholes, R. J. Whitman, *Science* **182**, 443 (1973).
4. A description of the system may be found in: *Patterns of Energy Consumption in the United States* (report prepared for the Office of Science and Technology, Executive Office of the President, by Stanford Research Institute, Stanford, California, Jan. 1972), appendix C. The three groupings larger than food processing are: primary metals, chemicals, and petroleum refining.
5. N. Georgescu-Roegen, *The Entropy Law and the Economic Process* (Harvard Univ. Press, Cambridge, 1971), p. 301.
6. *Patterns of Energy Consumption in the United States* (report prepared for the Office of Science and Technology, Executive Office of the President, by Stanford Research Institute, Stanford, Calif., Jan. 1972).
7. R. A. Rice, *Technol. Rev.* **75**, 32 (Jan. 1972).
8. Federal Highway Administration, Nationwide Personal Transportation Study Report No. 1 (1971) [as reported in Energy Research and Development, hearings before the Congressional Committee on Science and Astronautics, May 1972, p. 151].
9. M. Slesser, *Ecologist* **3** (No. 6), 216 (1973).
10. J. F. Gerber, personal communication (we are indebted to Dr. Gerber for pointing out that manures, even if used fully, will not provide all the needed agricultural fertilizers).
11. D. Chapman, *Environment (St. Louis)* **15** (No. 2), 12 (1973).
12. L. U. Mayer and S. H. Hargrove [*CAED Rep. No. 38* (1972)] as quoted in Slesser (9).
13. We have converted all figures for the use of electricity to fuel input values, using the average efficiency values for power plants given by C. M. Summers [*Sci. Am.* **224** (No. 3), 148 (1971)]. Self-generated electricity was converted to fuel inputs at an efficiency of 25 percent after 1945 and 20 percent before that year.
14. Purchased material in this analysis was converted to energy of manufacture according to the following values derived from the literature or calculated. In doubtful cases we have made what we believe to be conservative estimates: steel (including fabricated and castings), 1.7×10^7 kcal/ton (1.9×10^4 kcal/kg); aluminum (including castings and forgings), 6.0×10^7 kcal/ton; copper and brass (alloys, millings, castings, and forgings), 1.7×10^6 kcal/ton; paper, 5.5×10^6 kcal/ton; plastics, 1.25×10^6 kcal/ton; coal, 6.6×10^6 kcal/ton; oil and gasoline, 1.5×10^6 kcal/barrel (9.5×10^3 kcal/liter); natural gas, 0.26×10^3 kcal/cubic foot (9.2×10^3 kcal/m^3); petroleum wax, 2.2×10^6 kcal/ton; gasoline and diesel engines, 3.4×10^6 kcal/engine; electric motors over 1 horsepower, 45×10^3 kcal/motor; ammonia, 2.7×10^7 kcal/ton; ammonia compounds, 2.2×10^6 kcal/ton; sulfuric acid and sulfur, 3×10^6 kcal/ton; sodium carbonate, 4×10^6 kcal/ton; and other inorganic chemicals, 2.2×10^6 kcal/ton.
15. Direct fuel use on farms: Expenditures for petroleum and other fuels consumed on farms were obtained from *Statistical Abstracts* (*1*) and the *Census of Agriculture* (Bureau of the Census, Government Printing Office, Washington, D.C., various recent editions) data. A special survey of fuel use on farms in the 1964 *Census of Agriculture* was used for that year and to determine the mix of fuel products used. By comparing expenditures for fuel in 1964 with actual fuel use, the apparent unit price for this fuel mix was calculated. Using actual retail prices and price indices from *Statistical Abstracts* and the ratio of the actual prices paid to the retail prices in 1964, we derived the fuel quantities used in other years. Changes in the fuel mix used (primarily the recent trend toward more diesel tractors) may understate the energy in this category slightly in the years since 1964 and overstate it slightly in years before 1964. S. H. Schurr and B. C. Netschert [*Energy in the American Economy, 1850–1975* (Johns Hopkins Press, Baltimore, 1960), p. 774], for example, using different methods, estimate a figure 10 percent less for 1955 than that given here. On the other hand, some retail fuel purchases appear to be omitted from all these data for all years. M. J. Perelman [*Environment (St. Louis)* **14** (No. 8), 10 (1972)] from different data, calculates 270×10^{12} kcal of energy usage for tractors alone.
16. Electricity use on farms: Data on monthly usage on farms were obtained from the "Report of the Administrator, Rural Electrification Administration" (U.S. Department of Agriculture, Government Printing Office, Washington, D.C., various annual editions). Totals were calculated from the annual farm usage multiplied by the number of farms multiplied by the fraction electrified. Some nonagricultural uses are included which may overstate the totals slightly for the years before 1955. Nevertheless, the totals are on the conservative side. A survey of on-farm electricity usage published by the Holt Investment Corporation, New York, 18 May 1973, reports values for per farm usage 30 to 40 percent higher than those used here, suggesting that the totals may be much too small. The discrepancy is probably the result of the fact that the largest farm users are included in the business and commercial categories (and excluded from the U.S. Department of Agriculture tabulations used).
17. Fertilizer: Direct fuel use by fertilizer manufacturers was added to the energy required for the manufacture of raw materials purchased as inputs for fertilizer manufacture. There is allowance for the following: ammonia and related compounds, phosphatic compounds, phosphoric acid, muriate of potash, sulfuric acid, and sulfur. We made no allowance for other inputs (of which phosphate rock, potash, and "fillers" are the largest), packaging, or capital equipment. Source: *Census of Manufactures* (Government Printing Office, Washington, D.C., various recent editions).
18. Agricultural steel: Source, *Statistical Abstracts* for various years (*1*). Converted to energy values according to (*14*).
19. Farm machinery (except tractors): Source, *Census of Manufactures*. Totals include direct energy use and the energy used in the manufacture of steel, aluminum, copper, brass, alloys, and engines converted according to (*14*).
20. Tractors: numbers of new tractors were derived from *Statistical Abstracts* and the *Census of Agriculture* data. Direct data on energy and materials use for farm tractor manufacture was collected in the *Census of Manufactures* data for 1954 and 1947 (in later years these data were merged with other data). For 1954 and 1947 energy consumption was calculated in the same way as for farm machinery. For more recent years a figure of 2.65×10^6 kcal per tractor horsepower [illegible]lated as the energy of manufacture from 1954 data (the 1954 energy of tractor manufacture, 23.6×10^{12} kcal, divided by sales of 115,000 units divided by 28.7 average tractor horsepower in 1954). This figure [illegible]culate energy use in tractor [illegible] in more recent years to take some account of the continuing increase in tractor size and power. It probably slightly understates the energy in tractor manufacture in more recent years.

21. Irrigation energy: Values are derived from the acres irrigated from *Statistical Abstracts* for various years; converted to energy use at 10^6 kcal per acre irrigated. This is an intermediate value of two cited by Pimentel *et al.* (*1*).
22 Food processing industry: Source, *Census of Manufacturers*, direct fuel inputs only. No account taken for raw materials other than agricultural products, except for those items (pack[illegible] processing machinery) accounted for in separate categories.
23. Food processing machinery: Source, *Census of Manufactures* for various years. Items included are the same as for farm machinery [see (*13*)].
24. Paper packaging: Source, *Census of Manufactures* for various years. In addition to direct energy use by the industry, energy values were calculated for purchased paper, plastics, and petroleum wax, according to (*14*). Proportions of paper products having direct food usage were obtained from *Containers and Packaging* (U.S. Department of Commerce, Washington, D.C., various recent editions). [The values given include only proportional values from Standard Industrial Classifications 2651 (half), 2653 (half), 2654 (all).]
25. Glass containers: Source, *Census of Manufactures* for various years. Direct energy use and sodium carbonate [converted according to (*14*)] were the only inputs considered. Proportions of containers assignable to food are from *Containers and Packaging*. Understatement of totals may be more than 20 percent in this category.
26. Steel and aluminum cans: Source, *Census of Manufactures* for various years. Direct energy use and energy used in the manufacture of steel and aluminum inputs were included. The proportion of cans used for food has been nearly constant, at 82 percent of total production (*Containers and Packaging*).
27. Transportation fuel usage: Trucks only are included in the totals given. After subtracting trucks used solely for personal transport (all of which are small trucks), 45 percent of all remaining trucks and 38 percent of trucks larger than pickup and panel trucks were engaged in hauling food or agricultural products, or both, in 1967. These proportions were assumed to hold for earlier years as well. Comparison with ICC analyses of class I motor carrier cargos suggests that this is a reasonable assumption. The total fuel usage for trucks was apportioned according to these values. Direct calculations from average mileage per truck and average number of miles per gallon of gasoline produces agreement to within ± 10 percent for 1967, 1963, and 1955. There is some possible duplication with the direct fuel use on farms, but it cannot be more than 20 percent considering on-farm truck inventories. On the other hand, inclusion of transport by rail, water, air, and energy involved in the transport of fertilizer, machinery, packaging, and other inputs of transportation energy could raise these figures by 30 to 40 percent if ICC commodity proportions apply to all transportation. Sources: *Census of Transportation* (Government Printing Office, Washington, D.C., 1963, 1967); *Statistical Abstracts* (*1*); *Freight Commodity Statistics of Class I Motor Carriers* (Interstate Commerce Commission, Government Printing Office, Washington, D.C., various annual editions).
28. Trucks and trailers: Using truck sales numbers and the proportions of trucks engaged in food and agriculture obtained in (*27*) above, we calculated the energy values at 75×10^6 kcal per trucks for manufacturing and delivery energy [A. B. Makhijani and A. J. Lichtenberg, *Univ. Calif. Berkeley Mem. No. ERL-M310* (revised) (1971)]. The results were checked against the *Census of Manufactures* data for 1967, 1963, 1958, and 1939 by proportioning motor vehicles categories between automobiles and trucks. These checks suggest that our estimates are too small by a small amount. Trailer manufacture was estimated by the proportional dollar value to truck sales (7 percent). Since a larger fraction of aluminum is used in trailers than in trucks, these energy amounts are also probably a little conservative. Automobiles and trucks used for personal transport in the food system are omitted. Totals here are probably significant, but we know of no way to estimate them at present. Sources: *Statistical Abstracts*, *Census of Manufactures*, and *Census of Tran[illegible]tion* for various years.
29. Commercial and home refrigeration and cooking: Data from 1960 through 1968 (1970 extrapolated) from *Patterns of Energy Consumption in the United States* (*6*). For earlier years sales and inventory in-use data for stoves and refrigerators were compiled by fuel and converted to energy from average annual use figures from the Edison Electric Institute [*Statistical Year Book* (Edison Electric Institute, New York, various annual editions] and American Gas Association values [*Gas Facts and Yearbook* (American Gas Association, Inc., Arlington, Virginia, various annual editions] for various years.
30. Refrigeration machinery: Source, *Census of Manufactures*. Direct energy use was included and also energy involved in the manufacture of steel, aluminum, copper, and brass. A few items produced under this SIC category for some years perhaps should be excluded for years prior to 1958, but other inputs, notably electric motors, compressors, and other purchased materials should be included.
31. There are many studies of energy budgets in primitive societies. See, for example, H. T. Odum [*Environment, Power, and Society* (Wiley, Interscience, New York, 1970)] and R. A. Rappaport [*Sci. Am.* **224** (No. 3), 104 (1971)]. The remaining values of energy subsidies in Fig. 5 were calculated from data presented by Slesser (*9*), Table 1.
32. This article is modified from C. E. Steinhart and J. S. Steinhart, *Energy: Sources, Use, and Role in Human Affairs* (Duxbury Press, North Scituate, Mass., in press) (used with permission). Some of this research was supported by the U.S. Geological Survey, Department of the Interior, under grant No. 14-08-0001-G-63. Contribution 18 of the Marine Studies Center, University of Wisconsin Madison. Since this article was completed, the analysis of energy use in the food system of E. Hirst has come to our attention ["Energy Use for Food in the United States," *ONRL-NSF-EP-57* (Oct. 1973)]. Using different methods, he assigns 12 percent of total energy use to the food system for 1963. This compares with our result of about 13 percent in 1964.

Economic Strategy for Import-Export Controls on Energy Materials

Helmut J. Frank

Lifting the embargo, against the United States by the oil-producing Arab countries may alter the nature of the energy question from a temporary crisis to a long-run problem. With this shift, attention is likely to focus once again on fundamental issues such as the role of imported energy sources in total U.S. supplies, the feasibility and cost of pursuing domestic self-sufficiency, the use of agricultural and industrial exports for bargaining or retaliatory purposes, and the policy instruments most suitable for attaining desirable policy objectives. The choice of appropriate foreign trade policies affecting energy can go far toward assuring the country adequate supplies at reasonable costs; the failure to do so could be disastrous for the country's security, its economic strength, or both.

Determining the role of imported energy sources in the total supply stream would not be a problem if normal economic forces could be allowed to govern trade in energy: Trade would follow the law of comparative advantage. The United States would import those goods in which foreign countries have relatively the lowest costs (say, oil) and pay for them by exporting goods in which the U.S. cost advantage is greatest (say, foodstuffs). This trade need not, indeed it should not, be limited to direct bilateral exchange. To obtain maximum benefit from the uneven distribution of natural and human resources, goods and capital should be permitted to move freely across national frontiers in response to normal economic incentives.

The recent oil embargo has brought home to every American the fact that the conditions under which free exchange can function effectively have not been allowed to govern trade in energy materials. During the past few years, the Organization of Petroleum-Exporting Countries (OPEC) has become powerful enough to control production and raise short-run prices to

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RECEIVED
AUG 29 1974
State of Hawaii
LAND USE COMMISSION

EXHIBIT B

Testimonies presented in February 1973 before the Land Use Commission in opposition to the Lanai Company rezoning petition.

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Testimonies presented in February 1973 before the Land Use Commission in opposition to the Lanai Company rezoning petition.

February 28, 1973
San Francisco, CA

Hawaii State Land Use Commision
Honolulu, Hawaii

Testimony on Lanai Company's petition to rezone land on the island of Lanai:

Chairman and members of the State Land Use Commission:

I, Colbert Matsumoto am a resident of the island of Lanai, born and raised there and presently attending school on the mainland. I have followed the developments concerning the Lanai Company proposal for Lanai from the initial announcement of the plan in late 1971 until the hearing which your body conducted on Lanai on February 16, 1973. I have read the proposal and would like to express some of my sentiments about it.

Lanai Company's proposal for island-wide planning is a unique and commendable concept I feel since it can provide for the most orderly development of an island like Lanai. However, any such island-wide planning requires painstaking study and diverse participation in order to be drawn up in such a manner as to benefit the largest number of residents of that island. This need for more input appears to be one of the plan's most major shortcoming.

Lanai Company has given much lip service to community participation in development of the island yet not one ounce of community participation and input can be found in the proposal which was drawn up by people who have livedon Lanai for but a few years and only because their task has been to come up with a development plan.

The people on Lanai are presently in a desperate situation since all indications point to termination of pineapple operations on the island in a few years. Their lives depend on income from pineapple and with no other industry on the island to turn to, one can realize their floundering position in a sea of uncertainty. I am no casual observer commenting on their situation for my life too is bound up in the future of Lanai. My parents both work for Dole, and without the income they receive from Dole I could not continue to attend school. Yet, I cannot see supporting the proposal merely to insure their economic security in the future since the plan in no manner does insure any such security for the people of Lanai. This was the point I was able to hear Mr. Eddie Tangen of the ILWU eloquently put forward in behalf of the ILWU and it's Lanai members at the Lanai Advisory Committee hearing in 1972.

Resort construction on Lanai is no guarantee that pineapple workers will be able to find jobs in the hotels. Some may, but no one can honestly expect to have hotels provide a panacea for unemployed pineapple workers. Don Rietow of Lanai Company in response to Mr. Tangen's concerns, replied in an open letter to the people of Lanai that they would have first preference in resort job opportunities. He also made numerous assurances that development costs would be borne by the developing company and not the county or state. However, in my reading of his statement, none of it appeared in any way legally binding or not easily subject to revision. Lanai Company's petition is vague in too many areas.

At your Lanai hearing, some people spoke of how an increasing population would mean more jobs and increasing cultural opportunities. However, an inceease in population to 12,500 need not necessarily entail the creation of as many jobs as such a population typically would require because the proposed population is not a "typical" one. Examination of the proposal would show that a large number of this population would be "transient". That is, tourists and "second home residents" who would spend a couple of months of the yearon the island. Such a resident population would not require more tailors as was suggested at the hearing since they will more likely get their tailoring needs fulfilled in their permanent residence. They would not be interested in cultural activities since the primary reason for their coming to Lanai would be for what Lanai residents now have and enjoy, that is, the openness of the land, the hunting, fishing and quiet rural life. The presence of these "transients" though, and the agricultural-residential zoning to accomodate their "country homes" on a large portion of land now used for recreation, will eliminate much of now so beautiful about Lanai, and leave it subdivided into private property for the exclusive use of an elite.

The people of Lanai are in a difficult position and need something to pull them out of it. In their desperation they grasp for the nearest thing available to keep their heads above water and what they reach for may pull them under in the long run.

The answer to Lanai's plight will inevitably demand changes on the island. Resorts may be the only feasible answer to the economic problem. Population increase can bring benefits. But, wise development, wise planning requires time, patience, caution and input by not just a few professional planners. The residents of Kohala may be at least a little more fortunate that those of Lanai since they can participate in planning for thier future. The residents of Lanai will be denied this opportunity if this plan passes your body.

The people of Lanai are beautiful. They are an easy-going, friendly people. The lifestyle there is one of cooperation and sharing. They are a hardworking lot of people having struggled for many years on the pineapple plantation. Their paychecks have never been much but the joy of living on Lanai has offset this. They have good hunting, good fishing, beautiful land, clean air, sweet water and wonderful neighbors. Their lives are beautiful.

You hold in your hands the power to determine the future of these people. Radical change, I know will destroy them. May your decision on Lanai Company's petition reflect your responsibility to these gentle people.

Sincerely yours,

Colbert M. Matsumoto

Colbert M. Matsumoto

LIFE OF THE LAND
A GROUP FOR ECOLOGICAL RESEARCH AND ACTION

Submitted by Sophie Ann Aoki

Testimony before the State Land Use Commission February 16, 1973

Re: Petition by Lanai Co. for Rezoning

Life of the Land applauds the findings and recommendations of the Land Use Commission staff, taking exception to the agreement that tourism and some controlled form of second home development offer the best way of diversifying Lanai's economy. We believe the company unfairly justifies its plan in terms of the people here and reflects a continuation of certain trends that state officials have warned against.

The most widely accepted claim of the plan is of more jobs, mostly projected for the hotel industry. From the State's 1972 Tourism Impact Planning Study (TIPS) we know that:

1. Workers in the hotel industry are among the lowest paid compared to those in other sectors of the economy -- and rank close to the bottom of the list in terms of take home pay. Because of the wage-scale, the average education level of the workers is 10th grade, the average employee age is over 40 years, and half of the employees are women.
2. Earnings in the industry have increased less than those in other areas of the economy.
3. There is little job advancement in the hotel industry
4. The industry relies heavily on immigrant workers which increases social and economic costs to the State, thereby lowering the benefit--cost ratio of the industry.. The State must provide basic public service like schools, housing, police, fire protection, and hospitals for the newcomers and their dependents.
5. In view of the low wages offered by the industry, it is doubtful whether young people who have a choice will be willing to remain on their home islands to work in thoels. At the same time, the hotel industry will have to compete with manpower demands of other sectors of the economy -- expected to grow and offer higher paying jobs.
6. Absorbing agricultural workers may also have its limitations with many workers being incapable of making the transition. The occupational structural of plantation workers is different from those in the visitor industry so many workers are overskilled for hotel employment. If there is the possibility of other forms of agriculture besides pineapple and sugar, workers will probably remain in agriculture because of previous experince and higher agriculture wages.

In short, tourist development adds up to an industry that raises the economic expectations of many workers without generating the kinds of opportunities to meet those expectations.

7. Tourism increases the cost of certain goods and services within a community, most notably hosuing and shoreline recreation. In an agricultural community, these rising costs are not offset by a higher price in income. Tourists are generally willing to pay a higher price for a short period of time -- and this willingness drives prices up for everyone. Tourists are here only a short time, residents must pay high prices everyday.

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The State study also clearly defines how resort development aggrevates the increasing statewide housing shortage, skyrocketing land values and pressures for higher densities in resort development and increasing the need for low cost employee housing.

Lanai Company's contribution to the housing crunch throughout the state is for a bedroom community consisting primarily of vacation homes, resorts and condominiums.

The company discusses increases local landownbrship in terms of "opportunity" and consistently has refused to identify even estimated price ranges.

So long as the company is unable to publicly provide some idea of future al land and housing costs that will be within the reach of local residents— that part of the plan is a hoax.

The premise in the plan of controls of development densities through deed and lease agreements remains a legal xx pretense until backed up by an actual deed or lease agreement for your consideration.

The Study merits your compliance with its recommendations, in particular:
1. the reordering of priorities for middle and low cost housing, and open space and recreational areas;
2. a moratorium be declared on additional zoning for resort development because of the danger of overbuilding beyond tourism demand. We note that the Lanai Company plans for resort development were not included in the TIPS projections for future resort facilities and the warning of overbuilding; and
3. the Land Use Commission policy of granting zoning only on an incremental basis for large projects. We believe this to be the largestxxld land rezoning application beffre your Commission.

It is unquestionable that change will come to Lanai. The question is what kind of change, when, and how. What has been proposed is an optimum development plan for Lanai representing such a drastic change in present rural lifestyles.

We therefore request in addition to the recommendations oftt the State Land Use Commission staff the following:
1. The Land Use Commission's compliance with the Governor's Executive Order requiring an Environmental Impact Statement on "all major state actions that significantly affect theq quality of the physical and human environment." This means that before a Land Use Commission decision on this application is made, a full-blown EIS be done and reviewed.
2. Life of the Land questions the legality of three of the commissioners present and requests a legal ruling on those whose terms we understand to be expired.
3. The plan be made available to the residents of Lanai in a public building like the courthouse buildingk as is done in Honolulu and the island of Maui.

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TESTIMONY IN OPPOSITION TO LANAI COMPANY'S REQUEST FOR THE REZONING OF 22,340 ACRES OF CONSERVATION LANDS

My name is Dexter Del Rosario, a resident of Lanai, and presently a student at the University of Hawaii. This testimony is based on the possible implications the Lanai Company land development plan may have on the residents of Lanai.

One proposal plans to provide broader opportunities for land and home ownership. These plans call for, in the area to be zoned urban, rural residential, and agricultural residential, ½ acre to 22 acre lots, with an average of 7 acre lots.

A survey by the office of Economic Opportunity on low income population on Lanai report in March 1972 that "... occupations which paid the least in the State were the most plentiful on Lanai; laborers - median income $5,122 and operatives, $6,445. These median figure meant that half of those employed as laborers received less than $5,122 and half of those working as operatives were paid less than $6,445". The survey further points out the 21 percent of all households had annual income of less than $4,000. At the other end were 9 per cent, who made $15,000 or more. We are all aware of the severe land and housing crises facing Hawaii. Today the cost of a home averages $40,000 and higher. Also, if one considered financing to buy a home, today to make a $25,000 loan, one has to be making more than $15,000 a year.

Now as an example of the kind of land and home ownership opportunities offered by the plan in the first year of development, there will be available at Koele, 98 lots, with the average lot size at approximately 1.22 acres per lot. If the lots are sold at a minimum of 50¢ per square foot, as the previous Lalakoa subdivision were sold two years ago, the cost of one average size lot would be approximately $26,000. This is just the raw land cost! All this means that a minimum of 91 per cent of Lanai residents will be priced right out of the housing market, and consequently out of the plan's proposal to "improve the quality of life" for the Lanai Island residents by providing broader home ownership opportunities.

Another proposal of the plan would be to expand recreational opportunities and facilities. Being that the more popular recreational pastime of the residents is that which involve nature's resources such as hunting, fishing, camping, use of beaches and so forth, the mere occupation of the areas that provide these types of recreational shoreline resources are major assets of the Tourist industry and local residents also value highly shoreline resources consequently, the plan will create competition for these resources. For example, one of the more popular recreational areas is the Manele-Hulopoe area. The Lanai Company plan proposes a development of a population, at any given time, at 2,300 people. Another area is the Keomoku to Naha area, where the plan proposes a population of 3,500 people. It becomes questionable as to how the presence of Resorts, Country homes and supporting facilities of 2,300 people in the Manele-Hulopoe area and 3,500 people at the

Keomoku-Naha area will broaden or expand the kind of recreational opportunities popular with the local residents. The plan proposal to bring in tourists and new "residents" of the proposed country homes also brings the possibility of added undue inflationary pressures on the local economy. The Hawaii Tourism Impact Plan from the Department of Planning and Economic Development put out in 1972 stated:

> "Tourism increases the cost of certain goods and services within a community, most notably housing and shoreline recreation. In an agricultural community which is increasing in tourism, these rising costs are not offset by increases in income. Tourists are generally willing to pay a higher price than local residents for goods or services, since their demand is short-term. This willingness drives up prices. For example residents unhappy with crowded recreational areas may travel further to enjoy similar amenities, thus added costs."

The new residents, being able to afford the proposed country homes will have incomes considerably greater than local residents. Also they will be generally more willing to pay higher prices for goods and services.

According to the OEO's survey, Lanai is one of the most impoverished communities in Hawaii, but the peoples' attutudes do not totally reflect what the statistics show. Perhaps it is because we possess living conditions that prices cannot be placed on, such as uncrowded beaches, good fishing and hunting, low crime rate, and so forth, the kind of conditions others must go to great expense and inconvenience to experience, the rural quality and charm, Lanai Company hopes to retain but is only endangering.

The Lanai Company plan provides for "country homesites" that will be priced out of the reach of the great majority of local residents, contributing to the already severe housing crisis. It will provide for the development of resorts which encroach upon the resident's recreational area; where the kind of outdoor pastime popular with local residents are not mere recreation, but something inherent in the life style of the residents and to endanger these things is to endanger a part of the island's lifestyle and culture.

Lanai Company's plans will undoubtedly provide broader employment opportunities and a stronger, multifaceted economy, both of which are needed on Lanai and essential to Lanai's continued existence. But Lanai Company's venture into resorts, and high priced "country homes" is not the only alternative to obtaining "Job Security". Neither does Lanai Company's plan, being the only plan at this time, make it the best plan. Country living cannot be commercialized. Country living cannot be made into a commodity to be bought and sold and any attempt to do so will ultimately destroy that country life style.

Lanai Company's plan simply raises too many critical questions as to exactly how the local residents will benefit or suffer as a result of the plan. If as much time and expense as Mr. Donald Rietow, President of Lanai Company, has said were expanded to provide for the needs of the local people then these questions should have been and must be answered before this plan is implemented.

Lanai Company's development plan is indeed a good plan, but the basic question is, GOOD FOR WHO? It is highly questionable whether it is good for the local residents on Lanai and on these grounds, I urge you to reject Lanai Company's plan for rezoning until further studies can be made to obtain more detailed information as to how the drastic changes required by the Lanai Company development will affect the local residents.

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TESTIMONY IN OPPOSITION TO THE LANAI COMPANY'S REQUEST FOR RECLASSIFYING OF 22,000 ACRES OF CONSERVATION LANDS

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LAND USE COMMISSION

My name is Dennis Hokama, a former resident of Lanai, not a member of a "Honolulu based organization" as some would have you believe, but one who after having lived in this community for over 18 years can not help but feel himself a Lanaian. I am presently a teacher on leave of absence working for a masters degree. I am here tonight speaking in opposition to the Lanai Company's petition to have over 22,000 acres of conservation lands rezoned.

I am speaking in opposition to the petitioners request because I feel that the rezoning will lead to a poor public and social investment in what is to be a massive resort and second home type development project. The Hawaii Tourism Impact Plan from the Dept. of Planning and Economic Development(from here on referred to as TIP) which was released in 1972 shows quite clearly the poor investment in resort and tourist related developments due to rising public costs because of the rapidly increasing visitor market of lower spending tourists who are also heavy users of State recreational facilities. Another high public cost will be the cost of settling and servicing what the TIP anticipates as a labor market from the outside. "Young workers tend to move to Oahu because of more employment oppurtunities. In view of the low wages offered by the industry, it is doubtful whether young people who have a choice will be willing to remain on their home islands to work in hotels. At the same time, the hotel industry will have to compete with manpower demands of other sectors of the economy, which are expected to grow and offer higher paying jobs." TIP pg. 81

"Absorbing workers from agriculture may also have limitations. Many workers may be incapable of making the transition. More important, ~~the occupational structure of plantation workers~~ is different from those in the visitor industry. Some workers are overskilled for hotel employment. There is also the possibility that other forms of agriculture will slowly replace pineapple and sugar. If so, workers will probably remain in agricult-

because of previous experience and higher agricultural wages."
TIP pg. 81

"The remaining source of manpower is workers from the mainland and foreign countries. Housing shortages on the Neighbor Islands will limit the numbers of Mainland persons who can be accomodated to work in the hotels. Immigrant labor also will face housing problems and the State will incur added costs of providing basic public services for the newcomers and their dependents." TIP pg. 81 If Lanai does not have a housing crisis now, how will it be with 2,000 additional workers and their families?

"Foremost among the social costs," as indicated by the TIP pg. 18, "are the added population produced by the visitor industry and the changes involved in rapid transition from a rural to a high-cost, urban-oriented society."

Most important of my concerns is whether the Lanai Company's Plan for development, rather than conservation as they indicate, will really benefit the residents or is it just another venture in profit maximization? I tend to think that the case is the latter instance. The petitioner states that there will be "broader oppurtunities for land ownership." The smallest lots available for sale according to the land sales schedule is approximately a half acre. These are lots located in the beach areas therefore the assessed valuation will undoubtedly be high. At the going price 2 years ago , lots were selling at $.50 a sq. ft. in Lanai City. The half acre lot then would have sold for $11,000. The most important factor in determining who the buyer is going to be in any marketable commodity is the cost of that commodity. I do believe the residents have been priced out even before official figures have been released.

So it seems, then, that Lanai residents will be surrounded by a wealthy group of people on high priced lands. What kinds of effects will this have on the cost of living schedule for residents? The HOEO study released in 1972 Lanai Survey of Low Income Population points out very clearly the socio-economic status of the Lanai community as being below average in the county of Maui and decidedly below state-wide averages. Of course poverty guidelines are relative and depends to a great extent on the cost of living in the community. Implications of the Lanai Company Plan points conclusively to higher costs for residents. Along with these higher costs the TIP pg. 78 states "In general earnings of wage workers in the hotel industry are low compared to those in other sectors of the economy."

"Low weekly earnings in the hotel industry can be explained in terms of two factors: low average hourly earnings and fewer hours worked per week. Surprisingly, the number of hours worked per week do not noticeably vary according to fluctuations in occupancy rates." TIP pg. 80

"Hotel employment is also often characterized by a lack of advancement oppurtunities. In many instances on-the-job career trainings through which personnel could gain upward orientation and the skills for further advancements are unavailable. According to a recent report, inattention to the non-management employee, coupled with the historical tendency of the industry to offer low renumeration, has often attracted the disadvantaged and marginal employee to food service jobs with little prospect for upward mobility." TIP pg.80

It can then be easily concluded that the average income of the resident who decides to work in a tourist related capacity will not be any more, more probably less, than what he is currently making now, which is about $6.500 to about $4.500 for tourist related work, and yet his chances of advancement will be decidedly less. He will also be faced with a significantly higher cost of living. Poverty, then, may not only be a statistic but also an experience for Lanai residents.

I question whether the Lanai Company Plan will benefit the residents in the area of recreation. How much more fishing areas and how many more fishes will there be with the developments along the southeastern coastline, the primary fishing area?

How much more hunting for Lanai residents will there be when hunting becomes a greater marketable commodity with an increased population of 15,000? How often will the residents be going to the beaches with more people? Projected population for the Manele-Hulopoe area alone is 2,300.

The Lanai Company Plan calls for a 30% increase in agricultural lands and for the lands under pineapple cultivation to remain agriculture. How much of these additional lands are cultivable and what would be the cost of developing these marginal agricultural lands for cultivation?

According to the Lanai Company Plan water appears to be a very valuable resource. Pineapple presently requires one-half to one billion gallons a year. The development will require an additional one billion gallons a year. The total requirement for pineapple and the developments call for a water supply of 1½-2 billion gals. a year. Their studies as submitted to the Land Use Commission show a total potential of only 1.3 billion gals. per year, a deficit of 200-700 million gallons per year. This tends to put a careful balance between pineapple and the developments in their competition for water. If pineapple phases out, and since pineapple requires a relatively small water supply in comparison to other crops, won't the other developments rule out the possibility of finding an agricultural alternative for the 15,000 acres of pineapple lands?

In conclusion I would like to reiterate my position that I am in opposition to the rezoning request, since what it will lead to are: (1)higher public costs, as resort development trends already indicate, (2)the social costs are to high: workers will be earning less and the cost of living will increase significantly causing a disparity situation, and there will be a drastic increase in population and all its attributable ills, (3)a greater restriction of resident recreational oppurtunities and (4) the probable greater difficulty of finding agricultural alternatives due to the competition for water.

There seems to be influential people in support of the Lanai Company Plan who are attempting to discredit opposition efforts by questioning our intentions, rather than the merits of data supported evidence of the opposition. I guess red-baiting and witch hunting is still very much with us. It seems strange that proponents of the Plan keep referring to the future of Lanai but when those who are the true future of Lanai, the youthful residents here and those who have recently left the community, speak of the kind of future they do not want to experience, they are treated as exiled members of their homeland to be banished forever. Maybe this is what the author of the statement, "You can never go back home again.", meant because the home we once experienced and still fully remember and cherish will be bulldozed forever out of existence.

How can a future be constructed without utilizing input of those whose future it is all about? No wonderthere are such things as credibility and generation gaps!

Dennis S. Hokama

Feb. 16, 1973

TESTIMONY IN OPPOSITION TO LANAI COMPANY'S PETITION TO REZONE 22,000 ACRES OF LAND FOR THE DEVELOPMENT OF LANAI

My name is Harriet C. Minami. I am a long-time resident of Lanai and presently a teacher here at Lanai High School. I am speaking tonight not only as a resident, but as a social studies teacher who cannot but wonder what sociological impact Lanai Company's development plan will have on the people of Lanai.

On the surface, the plan sounds beautiful, very appealing - more jobs, more services, more stores, more recreational facilities, more cultural activities, more opportunities to buy land and to become home-owners. But, as far as I know, the sociological problems that may arise from this very growth and expansion have never been brought to the attention of the public.

Here, I would like to speculate on these problems. The Lanai Company's plan calls for the sale of land in huge lots - anywhere from half an acre to twenty acres. Half an acre is 21,780 square feet. Most of our lots, I believe, are in the neighborhood of six to seven thousand square feet. Lanai Company has never quoted prices for the lands that will be up for sale. Mr. Rietow explained this evening that the company cannot quote prices because prices depend upon many factors. So, let me use the figure 50¢ per square foot since that was the price we residents at Akahi Place, the new sub-division, paid for our land. Now, if you want to buy land in the Ranch area, at 50¢ a square foot, you would have to have at least $22,000 because the average size of the lots there, according to the plan Lanai Company submitted to the State Land Use Commission, will be 1.22 acres in the first development stage and 1.10 acres in the second development stage. If you have that kind of money, I suppose you could buy 2, 3, or even 4 lots, build apartments for rentals, and make fabulous profit in time. But who among us have that kind of money? Now, I'm not too sure that anyone will be allowed to build apartments on these lots because I'm not aware of the legalities of the deed. But regardless of how you intend to use the land, the fact remains that you will have to be quite wealthy in order to be able to buy in, in the first place. And chances are, people who are that wealthy will think nothing about building $50, $60, or even $75 thousand homes. The end result of this, I'm afraid, is that the present city will eventually become the inner city - the ghettoes or the slums of Lanai. Most of the houses people live in now are about 30 or 40 years old, maybe older. Right now, people living in these homes do not feel like "slum dwellers" because they're all in the same boat, so to speak. But, in 1992, these houses will be 50, 60 years old. And as more and more new and expensive homes begin to sprout all around them, people who will still be living in these old homes may begin to resent the contrast. They may begin to feel like impoverished "slum dwellers". It makes me wonder what kinds of problems and conflicts a situation such as this might create between the people of the "slums" and the people of the more affluent suburbia, not to mention the people of the exclusive country residences all along the coast from Naha to Keomuku. So this is one of the possible sociological problems I am very much concerned about.

I would like to touch upon another sociological problem I foresee. This is the conflict that may arise between the local residents and the tourists, especially the hotel guests at Manele. Lanai Company has assured us residents that we will still be able to use Manele Beach, but Lanaians, I am sure, do not want an over-crowded "Waikiki" beach on this island. Now as the residents continue to be crowded out by the tourists, their (residents') rising resentment and frustrations, I'm afraid, will eventually reach a breaking point. And when that happens, heaven knows what might follow. Please understand that I am not trying to create or invite problems. But the truth is, whenever a large number of "outsiders" take over a place local residents previously had almost exclusive use of, conflicts do and have occurred. This is a sociological and psychological fact. It would not be so bad if there were another good swimming and surfing area here for the local residents. But, as far as I know, there isn't any.

Of course, it may well be that these conflicts and problems will never arise, that the fears I expressed here tonight are exaggerated, unfounded fears. I am not a sociologist so I cannot with certainty say that these problems will arise. Nonetheless, as a social studies teacher, I felt it to be my responsibility to call the public's attention to the possibilities of these problems and conflicts arising if the Lanai Company's development plan, as proposed, does go through.

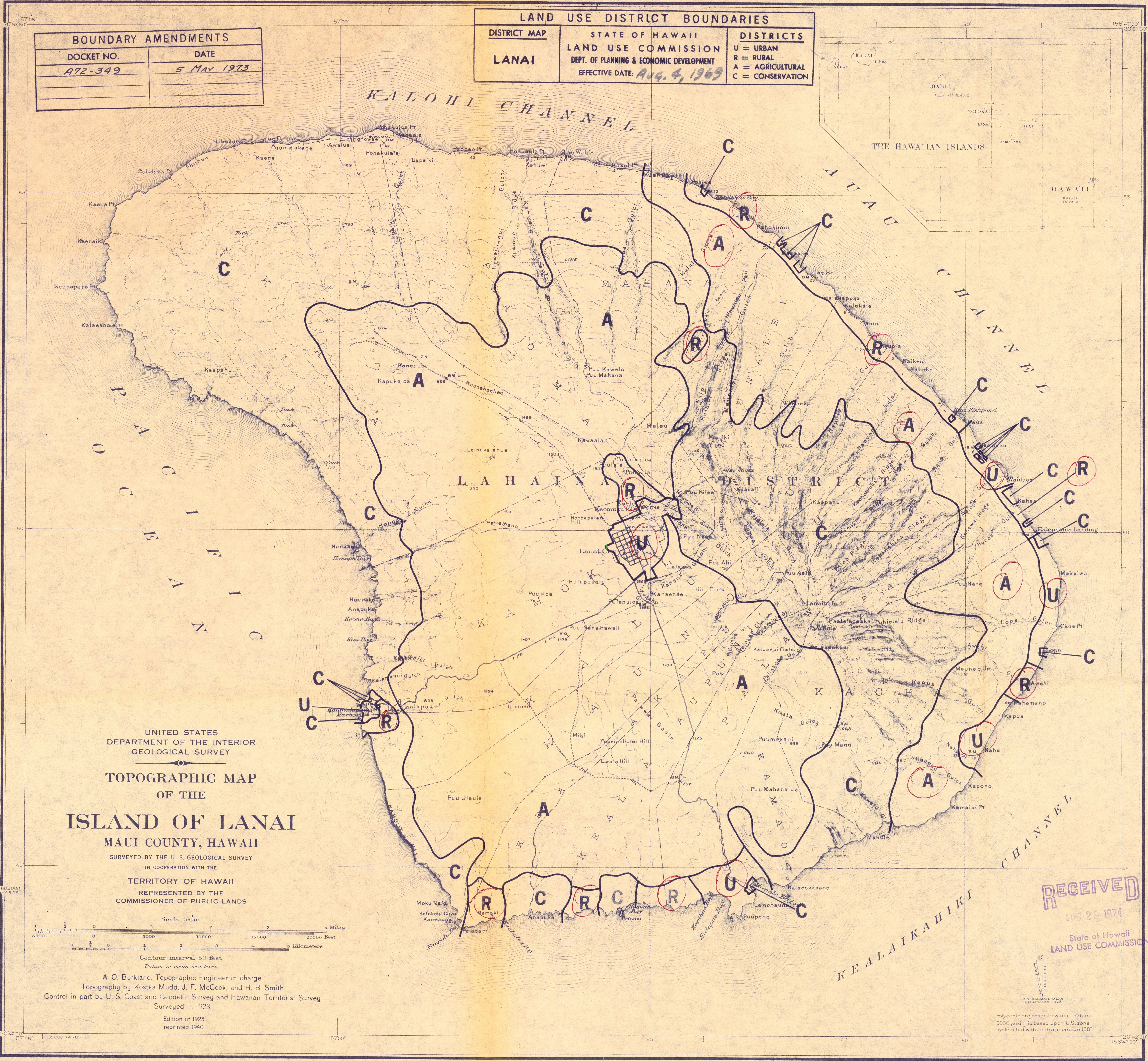
As I stated earlier in my testimony, on the surface, the plan is very attractive. But a closer study seems to reveal that the Lanai Company's claim that this plan will improve the quality of life for the residents of Lanai applies not to all of the residents - certainly not to the low-income residents - but to the wealthier, more affluent residents here and elsewhere.

I urge the members of the State Land Use Commission, therefore, to reject Lanai Company's request for rezoning until such a time that a thorough sociological impact study of its plan has been made. Mr. Ristow himself stated tonight that this is a total plan; thus a consideration of the plan must take into account all aspects of the plan. I agree. But it seems to me that Lanai Company has not included the sociological impact of the plan in its definition of total aspects.

Respectfully submitted,

Harriet C. Minami

February 16, 1973 (Miss) Harriet C. Minami



BOUNDARY AMENDMENTS
DOCKET NO. | DATE
A72-349 | 5 MAY 1973
LAND USE DISTRICT BOUNDARIES
DISTRICT MAP
LANAI
STATE OF HAWAII
LAND USE COMMISSION
DEPT. OF PLANNING & ECONOMIC DEVELOPMENT
EFFECTIVE DATE: Aug. 4, 1969
DISTRICTS
U = URBAN
R = RURAL
A = AGRICULTURAL
C = CONSERVATION
THE HAWAIIAN ISLANDS
KAUAI
OAHU
MOLOKAI
MAUI
HAWAII
KALOHI CHANNEL
AUAU CHANNEL
KEALAIKAHIKI CHANNEL
PACIFIC OCEAN
LAHAINA DISTRICT
Lanai City
Kaena Pt
Keanapapa Pt
Kaumalapau Harbor
Manele Bay
Halepalaoa Landing
UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY
TOPOGRAPHIC MAP
OF THE
ISLAND OF LANAI
MAUI COUNTY, HAWAII
SURVEYED BY THE U. S. GEOLOGICAL SURVEY
IN COOPERATION WITH THE
TERRITORY OF HAWAII
REPRESENTED BY THE
COMMISSIONER OF PUBLIC LANDS
Contour interval 50 feet
Datum is mean sea level
A. O. Burkland, Topographic Engineer in charge
Topography by Kostka Mudd, J. F. McCook, and H. B. Smith
Control in part by U. S. Coast and Geodetic Survey and Hawaiian Territorial Survey
Surveyed in 1923
Edition of 1925
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